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GOVERNMENT OF INDIA

DEPARTMENT OF INDUSTRIES AND SUPPLIES

REPORT

OF THE

PANEL ON FINE CHEMICALS, DRUGS AND PHARMACEUTICALS

सत्यमेव जयते

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REPORT OF THE PANEL ON FINE CHEMICALS, DRUGS AND PHARMACEUTICALS.

INTRODUCTORY :—A Panel was formed by the Government of India in the Department of Planning and Development to consider and make recommendations to them regarding the development of the Fine Chemicals, Drugs and Pharmaceuticals Industries. The Panel consisted of the following :—

Col. Sir R. N. Chopra, M.D., I.M.S.—*Chairman*.
Lt. Col. Sir S. S. Sokhey, M.D., I.M.S.—*Member*.
Dr. J. N. Ray, D.Sc. ,,
Dr. K. A. Hamied, Ph.D. ,,
Dr. Habib Hasan, Ph.D. ,,
Dr. V. Subrahmanyan, D.Sc., F.R.I.C. ,,
Mr. C. J. Fielder, B.Sc., F.R.I.C. ,,
Mr. N. Adhikari, M.Sc. ,,
Mr. M.B. Amin, Dipl. Ing. ,,
Dr. M. K. Maitra, Ph.D., D.I.C.—*Secretary*.

Dr. B. B. Dikshit, M.R.C.P., Ph.D., Dr. K. Ganapathi, D.Sc. and Dr. B. C. Guha D.Sc., were subsequently co-opted as members of the Panel.

2. The following general directive was issued by the Government of India to indicate the scope of the Panel and the procedure to be followed by it :

" It is the function of Panels to make recommendations to Government regarding the development of industries, both existing and new. These recommendations should be so framed as to enable Government to prepare a detailed phased plan for the five years following the cessation of hostilities as the first stage of a 15-year plan of industrial development for the whole country.

" In order to assist them to formulate recommendations, Panels will be supplied, as far as possible, with factual information prepared by the Panel secretaries. In the case of new industries, the information will consist of a general survey of the industry and the importance of starting it in India, the availability of raw material, the power requirements, the demands of the Indian markets and the probabilities of exports. In the case of existing industries, the information will naturally be more comprehensive ; it will indicate in addition, the location of existing units, the types of goods produced, the total production under each category and the assistance if any, given by Government. These items are to be regarded as illustrative and not exhaustive.

" Government will give each Panel, as a basis for discussion, the provisional target to be aimed at in the first five-year period and, wherever possible, of the target to be reached in 15 years.

" The recommendations of the Panels should cover the following points :—

(1) The scope and extent of development, including the type of products recommended.

(1-A) The estimated requirements of capital goods together with such details of these requirements as may be available in India and how much should be imported from abroad.

(2) Whether the industry should be under Government ownership either on grounds of national interest or because private capital is unlikely to take it up, and if so, whether it should be wholly or partly managed by Government.

(3) In the case of industries to be developed other than under State ownership, the capital required for such development, whether the whole of it is likely to be available by public investment and, if not, the extent to which Government assistance may be required.

(4) The extent to which technical advice from abroad may be necessary.

(4-A) The availability and the future requirements of technical personnel so as to obtain a clearer indication of the present short-comings and future needs.

(5) The manner and the degree of co-operation with foreign firms considered necessary and desirable, both as regards capital and management.

(6) The location of the industry.

(7) The nature of the assistance required from Government in the form of protective duties, bounties, research grant, expert advice etc.

(7-A) The relative incidence of the import duty on the finished goods in comparison with the duty on the raw materials from which they can be manufactured.

(8) If the industry is to be under private ownership and management, what controls, if any, should be exercised by Government.

(9) What should be the organisation of the different units of the industry, *e.g.*, should there be an industrial association ? Would a cartel be desirable ?

(10) The stages by which the industry should be developed.

(11) Should the industry cater for the export market ?

(12) Should the industry be developed, as in Japan, on the cottage industry basis and, if so, to what extent ?

" Although, as stated above, the panels may recommend the grant of protection, it will not be their function to consider broad questions of international trade and commercial policy

" Joint meetings of the Panels should be held, wherever necessary, to secure co-ordination particularly where the processes and the products of one industry are connected with those of another.

" Some of the Panels have been drawn broadly and it may be necessary to co-opt members for dealing with specific branches of the industry. Members may be co-opted by the Chairman in consultation with the Industrial Adviser.

" Before submitting recommendations, Panels should consult Provincial Industrial Committees, particularly in the matter of location of industry. They should also, where the circumstances of the case require it, consult Industrial Committees in States or State Governments/Durbars. The recommendations should be submitted to Government through the Industrial adviser."

3. A preliminary note on the manufacture of Fine Chemicals, Drugs & Pharmaceuticals by the Secretary, ' A survey of Drug Industry in India' by Dr. J. N. Ray and a note on ' Coal tar production and refining in India' by Mr. C. J. Fielder were circulated amongst the members of the Panel before its first meeting.

The meetings of the Panel were held on the following dates :—

The first meeting was held on the 5th and 6th October 1945.

The second meeeting was held on the 18th and 19th January 1946.

The third meeting was held on the 3rd and 4th May 1946.

The Panel is greatly obliged to several officials and non-officials who have helped it with information and advice. It will not be possible to name them all individually. The Panel would, however, like to express its special obligations to Dr. B. Mukerji, Director, Bio-chemical Standardisation Laboratory, for the co-operation and help he has rendered and to Dr. B. N. Manjunath, Chief Editor, Dictionary of Economic Products & Industrial Resources of India, for allowing the article on ' Coal Tar production and refining in India ' by Mr. C. J. Fielder, which was written for the Dictionary, to be made available to the Panel.

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DEFINITION:—

4. *Fine Chemicals, Drugs and Pharmaceuticals.*—The line of distinction between fine chemicals and heavy chemicals is not always clear. Sulphuric acid, caustic soda, sodium carbonate, etc., which are produced and consumed in very large quantities are usually described as heavy chemicals, while articles such as acetanilide, ethylene glycol, sodium citrate etc., which are manufactured in comparatively small quantities are described as fine chemicals. The vast majority of these are organic compounds and their total number runs to thousands. Fine Chemicals are generally consumed directly, in contrast to heavy chemicals which serve as raw materials for the production of other substances.

5. A considerable proportion of the fine chemicals is used as drugs. In addition, drugs are obtained from vegetable, mineral and animal sources. Pharmaceuticals are preparations of Drugs made up for use.

6. *PRESENT POSITION OF THE INDUSTRY.*—The Fine Chemicals, Drugs & Pharmaceuticals Industry developed considerably during the present war and many firms produced fine chemicals, and drugs; but it must be admitted that this industry is yet in its infancy in this country. A large number of alkaloids

such as strychnine, ephedrine, caffeine, etc., are being produced on a large scale. Many firms have, however, confined their attention to mere refining and bottling the substances which could not be produced in the country. Synthetic drugs produced in this country at present are mostly made out of imported materials. To place the manufacture of Drugs and Pharmaceuticals on a firm footing, it is of fundamental importance that Fine Chemicals should be produced in the country in requisite quantities.

7. *OBJECT TO BE ACHIEVED.*—The Panel considers that it should be the object to make India self-sufficient in regard to Fine Chemicals, Drugs and Pharmaceuticals within the next 15 years. In a vast tropical country such as India, the requirements of drugs are large. The country must produce all essential drugs and make them available for the use of the masses.

8. *GENERAL SCHEME OF PRESENT REPORT.*—It has not been considered necessary, nor would it have been possible to deal individually with the vast number of fine chemicals and drugs. The main sources of these and the general problems connected with their manufacture have been discussed in this report. Attempt has been made to focus attention on certain drugs and chemicals which are of special importance and the large scale productions of which are urgently required in this country. The difficulties which are at present hampering the production have been considered and the means by which these could be removed and the production could be placed on a sound basis have been indicated.

9. *RAW MATERIALS FOR THE MANUFACTURE OF FINE CHEMICALS AND DRUGS*—The raw materials from which fine chemicals and drugs are derived may be divided into the groups mentioned below. The production of these groups of articles will have to be sufficiently developed as first essential to the manufacture of fine chemicals and drugs on a large scale :

(*a*) *Inorganic Chemicals*, such as Chloro-sulphonic, sulphuric, nitric and hydrochloric acids, sodium hydroxide, sodium carbonate ; sulphur, phosphorus, ammonia ; chlorine, bromine, iodine ; metals such as arsenic, antimony, sodium, potassium, calcium, mercury, iron, zinc etc., and their derivatives.

(*b*) *Coal distillation* products such as benzene, toluene, naphthalene, anthracene, pyridine, phenol, higher phenols, etc.,

(*c*) *Wood distillation products,* such as methyl alcohol, acetic acid, acetone, etc.,

(*d*) *Fermentation products* such as ethyl alcohol, butyl alcohol, fusel oil, acetic acid etc.,

(*c*) *Petroleum products* such as petroleum ether, petrolatum (Vaseline), liquid petroleum, paraffin wax etc.,

(*f*) *Animals products*, such as tissues and glands of animals.

(*g*) *Vegetable products*, such as roots, barks, flowers, leaves and seeds of plants.

(*h*) *Synthetic Chemicals* derived from acetylene, ethylene and other aliphatic chemicals including products obtained by hydrogenation of carbon monoxide etc.

10. *Inorganic Chemicals.*—The successful manufacture of Fine Chemicals and Drugs is to a great extent dependent on the availability of certain basic chemicals such as the main acids and alkalies, common inorganic sulphates and phosphates, and essential gases such as Chlorine, ammonia, carbon-dioxide, Hydrogen etc. Sufficient quantities of almost all these chemicals are available and their further expansion has been considered by the Heavy Chemicals Panel, which has made recommendations for increased production of these at commercial rates. Hence, nothing further need be written about them here.

11. *Distillation Products of Coal.*—These constitute some of the most valuable raw materials. It would be necessary to develop coal distillation industry to the furthest possible extent and to place it on a sound and rational basis.

12. Coal distillation is carried out primarily for the purpose of producing either metallurgical coke or coal gas. In India over 90% of the coal distilled is coked in high temperature coke ovens, the main product (coke) being to a very large extent consumed in the Iron and Steel Industry. The quantity of coal distilled in gas retorts in India is comparatively small and is limited to that processed by the Bombay and Calcutta Gas Companies. The potential coking capacity of coke ovens in India is estimated at 3·5 million tons of coal per annum, but owing to the shortage of Coal the out-put of Coke has been very seriously reduced during the last 3 years, or so.

13. Coal Tar produced represents only approximately 2·5% by weight of the Coal distilled in the Coke ovens. In 1941, the quantity of Coal Tar produced in India was 80,000 tons of which approximately 60,000 tons were distilled, but due to coal and fuel shortage these quantities have been very greatly reduced and the amount of tar available for distillation dropped to 50% approximately of the pre-war figure with the result that the distillery plants have only been partially engaged.

14. Low boiling Tar Bases (Pyridine) etc., are present in Gas Tar but only in very small amounts. Indian Coal Tars have only traces of benzene and toluene and contain about 5% of Napthalene, tar acids (phenol, cresol etc.,) and tar bases (pyridine etc.,). Approximate war time production from Indian Coal tars has been as follows :—

Naphthalene	600 tons per annum.
Phenol	50 tons per annum.
Cresols	100 tons per annum.

In the case of Phenol the potential output from Coal Tar is quite inadequate and the greater part of the estimated demand must therefore be met from synthetic production. In the case of Cresols the potential production should be capable of meeting 50% of the estimated demand.

15. Coal distillation gases, after separation of Coal Tar and before being used as fuel are being stripped of Crude Benzol which may be refined to yield Benzene, Toluene and Xylenes. (Solvent Naphthas). Besides the two small recovery plants at Bararee Coke Co., and State Railways Colliery, Giridih,

E. I. Railway, the important Benzol Recovery plants are situated at the two main Steel Works (Tata Iron and Steel Co., Jamshedpur and Indian Iron and Steel Co., Ltd., Hirapur). These Recovery units are the property of the Government of India, but are operated on behalf of the Government by the respective Steel Companies under agreement for a certain number of years. In the event of the Government deciding at any time to discontinue operation of these plants and to dispose them off the Steel Companies have the option to acquire them. The capacity of these Benzol Recovery Units is as follows :—

Benzene	2·1 million gallons per annum.
Toluene	0·42 million gallons per annum.
Solvent Naphtha	0·10 million gallons per annum.

From the above it will be seen that the " Coal Tar Industry ", *i.e.*, the production of Coal Tar at the Works of the Iron and Steel Cos. and the distillation and by-product refining at the distillation plants is established in India and has been for some time producing certain by-products required by the Fine Chemicals Industy. Benzene and Toluene are produced in Coke Oven Gas Recovery Units at the Steel Works. These plants are Government owned and it is desirable that the Government of India should continue them in operation, utilising the products as a motor fuel until such time as the fine chemical industry is ready to absorb them.

16. The by-products obtained from Coal Tar distillation are no longer under statutory control imposed during the war, but there should be no difficulty in these products being produced and earmarked for the Fine Chemicals Industry.

17. The coke ovens in India are primarily designed to produce metallurgical coke. Consequently, the temperature of coking is high. Naturally such tars owing to polymerisation become richer in Naphthalene hydrocarbons. The best tar suitable for by-product recovery is obtained where the temperature of coking is comparatively low. But the coke from such ovens is not entirely suitable for metallurgical purposes. It is for this reason that large scale modification of the coke ovens cannot be immediately carried out. The Fuel Research Board may well consider the problem connected with the production of tar more suitable for by-product recovery from Indian coal. The Government of India should make available to the industry all data that they may possess on the distillation of Indian coal.

18. The manufacture of intermediate and synthetic products from the primary coal tar products has not yet been developed in the country. The most important basic material essential for such development is, however, Benzene, which is now available in good quantity. The coal tar intermediates for the preparation of drugs and dyes are common, and there should be a close co-ordination in the plans for the development of the manufacture of dyes and drugs in this country.

19. *Wood Distillation.*—There is at present only one wood distillation plant in India, situated in Mysore. This is capable of carbonising about 250 tons of wood per day. The by-product recovery plant is able to treat daily about 30,000 gallons of wood distillate and produces the following products :—

Calcium acetate,
Methyl Alcohol (crude and refined),
Methyl Acetone,
Refined wood tar,
Wood Tar pitch,
'Black paint,'
and wood preservative.

20. Until recently, the greater part of the production of calcium acetate was taken by the Government of India for the preparation of acetone. Acetone is now made in the Government of India factory from ethyl alcohol. The Mysore Iron and Steel Works propose to make arrangements for the direct recovery of acetic acid from the pyroligneous liquor. There is a considerable demand in India for acetic acid, which is estimated at present to be between 250 to 300 tons per year. During the war the demand was considerably higher and it is expected that the demand for acetic acid by the end of the next ten years may go up to 1,000 tons per annum. There is also a good demand for methyl acetone as a solvent, in various industries. Formaldehyde, obtainable from methyl alcohol, is used for the manufacture of synthetic resins, in the tanning industry and as an antiseptic. The demand for formaldehyde is steadily increasing and is expected to be not less than 1,000 tons per year by the end of next ten years.

21. New processes have been evolved, however, for the manufacture of acetic acid, acetone, methyl alcohol and formaldehyde. In industrially advanced countries, relatively small fractions of these materials are now produced from the distillation of wood. Acetic acid is manufactured from acetaldehyde, derived from acetylene or by the oxidation of ethyl alcohol. It is also produced by fermentation. Acetone is prepared by fermentation processes. Methyl alcohol is synthetically prepared from carbon monoxide and hydrogen, and formaldehyde is prepared from it. It will take some time before the above processes are properly developed in the country. In the meantime, particularly in parts of India where there is demand for wood charcoal and suitable varieties of wood are available cheaply and in abundance, the possibility of economic working of wood distillation plants may be further examined.

22. *Fermentation Products.*—Ethyl alcohol is the only product which is produced in India on a large scale by using the process of fermentation. The Panel on Sugar, Alcohol and Food Yeast has recommended a scheme for large increase in the production of anhydrous power—alcohol from molasses. The fermentation process should also be developed for the preparation of butyl and amyl alcohols and products such as lactic acid, butyric acid, gluconic acid, acetic acid, citric acid, glycorol, acetone and 1-Sorbose, which is a necessary intermediate in the synthetic production of ascorbic acid or vitamin C. The preparation of malt on a large scale is one of the industries, which should also be developed.

23. The fermentation industry is of the greatest importance to the country and its development should be taken in hand without delay. Some of the existing alcohol distilleries fabricated in the country are working efficiently and give the hope that other fermentation products could also be produced successfully. Any special difficulty arising out of an individual process of fermentation and on account of high temperatures prevailing in the country could be overcome successfully.

24. *Petroleum Products.*—Apart from petrol, kerosene and lubricating oils, crude petroleum yields a number of products used in the drug industry. There are at present two refineries in India for the refining of crude petroleum, one of these is in Assam and the other is in the Punjab. It should be possible to obtain from indigenous petroleum India's requirement for the following products :—

(1) Petroleum ether,

(2) Liquid petroleum or white mineral oil,

(3) Paraffin wax.

25. *Animal Products.*—In the ten big cities of India, namely Calcutta, Bombay, Delhi, Madras, Hyderabad, Lahore, Karachi, Lucknow, Dacca and Bangalore, over three million sheep and goats, and over three hundred thousand buffaloes, bullocks, cows and calves are slaughtered per annum. Though many of the animals handled at these slaughter houses are of poor quality and undernourished, the amount of glandular material obtainable from these is adequate enough to meet the greater part of the country's requirements for insulin thyroid, adronaline and posterior pituitary exratcts, liver extracts etc.

26. Adrenaline, thyroid and pituitary extracts are now being made by the Indian pharmaceutical concerns. It should not be difficult to greatly extend this production. Large quantities of liver extracts, both for oral and parenteral use, are also being made in the country. Animal bile is being used for the preparation of sodium taurocholate and glycocholate and dehydrocholic acid. In these also India could be mostly self-sufficient.

27. At present the arrangements for the collection of animal tissues and glands from the slaughter houses are very unsatisfactory. The materials should be made available to the manufacturers in a fresh condition to obviate any possibility of deterioration. Quick removal of the glands etc., after slaughter and their immediate freezing on the spot will require to be provided. Cheap transport facilities in cold storage will also have to be arranged.

28. Vaccines are produced in the country in large quantities and the present needs of the country are being met. The Government laboratories have among them a production capacity of about 8 million C. Cs. per month of bacterial vaccine. The capacity of production of private firms are 22 million C. Cs. per month. This production can be increased if larger quantities of vaccines are needed. Besides these existing laboratories, it is recommended that all Provincial Governments should organise their own bacteriological laboratories in the near future. Some private firms have also been making bacterial vaccines. The production in these, it is expected, will continue to increase.

As regards rabies, vaccines and vaccine lymph the existing Government laboratories can adequately meet the demands. Stoppage of supplies of Agar-Agar from Japan produced difficulties in the manufacture of vaccines during the war. This difficulty has been successfully met by the production of Agar-Agar from indigenous sources. It is necessary that the manufacture of Agar from indigenous sources should be further developed.

29. In recent years increasing quantities of antitoxins and sera of good quality are being made in the country. The present demand for these products is small but it would increase as medical relief organisations in the country develop. To meet the increasing demand it is recommended that all Provincial Governments should organise laboratories. In addition to the Government laboratories some commercial firms have also been producing anti-toxins and sera and there is no doubt that they will also increase their production.

A note by Sir S. S. Sokhey on the manufacture of Vaccines, Anti-toxins and Sera may be seen in Appendix X.

30. *Vegetable Products.*—(Including fixed and Essential oils).

India is favourably situated regarding the preparation of vegetable drugs; there is a wide variety of soil and climatic conditions, in which plants of all kinds can be grown. Apart from the large number of drugs used in the indigenous systems of medicine about 75% of the vegetable drugs mentioned in the British Pharmacopoeia can be prepared from plants grown in India. Certain of the Indian plants yield drugs which though not identical to those recognised in B. P. and B. P. C. have therapeutic properties similar to expensive imported remedies. Some of these are Ipomia Terpothum, Picrorrhiza Kurruoa, Polygola chinensis etc. Tinctures and extracts of these drugs have been made. Important drugs such as codein, quinine, ometin, strychnine, ephedrine, caffeine, santonin, etc. are also already being made in the country.

31. With careful cultivation, the resources of the country for some of the more important vegetable drugs could be greatly increased. The most important need at the present moment is to very greatly increase the production of cinchona. The cultivation of such plants as pyrethrum, ipecac, artomesia, etc. should also be greatly increased. A recent successful cultivation has been of Ergot of rye in the Nilgiris. The cultivation of this fungus should be carried out under strictly controlled conditions, in consultation with the Agricultural Department. Steps to be taken to increase the cultivation of medicinal plants should have in view not only the requirements of the country but also the export trade. Medicinal plants growing in the country are a real wealth of the nation and this wealth should be fully exploited. An inquiry should be instituted into the whole question of production of these drugs on a large scale ; to improve quality and reduce cost, to enable Indian products to meet foreign competition.

32. At present there is no organisation for the cultivation and sale of vegetable drugs. The manufacturers have to obtain their requirements from the local dealers. The roots, barks, leaves, etc., of plants as they are available are often in unsatisfactory condition and deficient in their drug content. There is no system of grading of crude drugs. Right species and types are not

available and spurious substitutes are often passed in their places. There should be a Government organisation in each province, or group of provinces, for improvement in cultivation and collection of medicinal plants. The Government should also organise stores where vegetable drugs of all kinds, properly stored and graded, would be available in good condition to drug manufacturers.

33. Plants from which important fixed and essential oils are obtained namely chaulmoogra, castor, linseed, sandal wood, citronella, eucalyptus, palmrosa, lemon grass oil, cardamom, etc., are all grown in this country. India has got adequate resources for the distillation of essential oils. If the raw materials are properly collected, adequate quantities of oils could be produced which will not only be sufficient for the internal demand, but will leave enough for export purposes.

34. The subject of the essential and fixed oils is being dealt by the panel on Oils and Soaps. The present panel recommends, however, that for the increase of production of these oils the following measures may be taken :

(i) Forests and wild grasses yielding essential oils should be preserved from damage with the help of the Revenue and Forest Departments, in order that the produce could all be utilised.

(ii) The Agriculture Department should carry on propaganda and give necessary help to the cultivators in cultivating and selling varieties of grasses seeds fruits, etc., yielding essential oils.

(iii) Selected varieties yielding more oil should be grown.

(iv) The distillations should be carried out in well planned and scientific manner so that maximum yields may be obtained.

(v) Marketing should be properly organised so that the products sold are not adulterated. This would help to build up a reputation for the Indian products and increase its demand.

35. *Synthetic Chemicals.*—In addition to the large number of chemicals obtained by direct distillation or extraction from natural sources, such as coal, wood, plants, etc., chemists have been able to build up an increasing number of valuable materials from simple substances. Some of the most important chemicals used in medicine have been prepared synthetically. Local and general anaesthetics such as veronal, avipan, novocaine, etc., highly active antiseptics such as acriflavine, crystal violet, D. D. T., etc., diuretics, antipyretics, hypnotics and sedatives, etc., are all being prepared by synthetic means. Many of the active principles of natural drugs, vitamins and hormones and the highly important modern chemo-therapeutic remedies such as sulphanilamide, sulphathiazole, etc. have also been manufactured synthetically.

36. A vast quantity of synthetic chemicals have been prepared in recent years in scientifically advanced countries from sources other than the products of distillation of coal. Nearly 2,000 million pounds of these materials, valued at 266 million dollars, were produced in U. S. A. alone in 1940. It is essential that this important branch of synthetic chemical industry which has so far been neglected in India should be properly developed. By catalytic hydration

of acetylene, acetaldehyde is formed, from which by catalytic oxidation, acetic acid is produced. Synthetic acetic acid is gradually replacing the acid obtained by wood distillation. By chlorination of acetylene, tetrachloroethane is formed, and from this an important solvent, trichloroethylene, is prepared. Other chlorinated hydrocarbons, such as perchloroethylene, pentachloroethylene etc., are also made from acetylene. Vinyl acetate, prepared by the action of acetic acid on acetylene, is hydrolysed to form polyvinyl alcohol. The rubber substitute neoprene, is a polymer of chloroprone, which is derived from acetylene and chlorine.

37. From ethylene prepared from alcohol by catalytic dehydration, or from petroleum cracked in the vapour phase, a series of important chemicals are synthesised. Ethylene glycol is obtained from ethylene. The monoethyl ether of ethylene glycol is an important solvent for gums, resins and nitrocellulose.

38. Methyl alcohol is now mostly prepared synthetically from carbon monoxide and hydrogen. In the United States of America, 24 million gallons of synthetic methyl alcohol were prepared in 1940, as against 5 million gallons produced from wood distillation. By varying the catalyst and altering the conditions of reactions, methane, methanol and higher alcohols are formed from carbon monoxide and hydrogen. Methyl alcohol or methanol forms the raw material for the preparation of methyl chloride and formaldehyde.

39. Synthetic chemical industry has hardly been developed in this country. A few articles are prepared on a laboratory scale mostly from imported starting materials. The preparation of synthetic methyl alcohol from carbon monoxide and hydrogen and of synthetic chemicals from acetylene, ethylene etc., will have to be developed on a large scale and the distillation products of coal such as benzene, toluene, naphthalene, anthracene should be available in sufficient quantities. Synthetic production of drugs and fine chemicals will have to be carried out under the supervision of trained chemists and the availability of chemists with sufficient skill in chemical operations is an essential requirement.

40. TARGETS OF PRODUCTION.— In order to achieve the object of making India selfsufficient in regard to the more important Drugs and Fine Chemicals the following figures of production should be reached within the next 10 years :—

DRUGS.

	Production targets per annum.
Quinine	2,000,000 lbs. per annum in 15 years
Morphine	3,000 lbs. per annum in 10 years
Codein	1,500 lbs.
Caffeine	30,000 lbs.
Strychnine	16,000 lbs.
Ephedrine	5,000 lbs.
Santonine	3,000 lbs.
Emetine	2,000 lbs.
Belladona pulvarata	50,000 lbs.
Mepacrine	160,000 lbs.
Pamaquine	5,000 lbs.
Sulpha Drugs	500,000 lbs.

Penicillin	1,000,000 million units.
Streptomycin	as much as possible.
Sulpharsphenamine	100,000 lbs.
Neoarsphenamine	
Para-carbamino phenyl arsonic acid	
Procaine hydrochloride	500 lbs.
Cocaine hydrochloride	100 lbs.
Percaine	25 lbs.
Atropine	150 lbs.
Veronal	25 tons.
Lumenal	
Hexamine	50 tons.
Argenti Proteins (Protargol)	5 tons for medicinal use.
Aspirin	50 tons.

Vitamins.

Shark Liver Oil	1,000,000 gallons of oil of average potency of 6,000 units per gm.
Vitamins A, B groups, C and D	Targets of production have not been fixed for these. It is understood that the Technical and Planning Panels of the Food Dept. are dealing with this question.

Hormones.

Adrenalin (base)	50 lbs.
Desoxycorticesterone	10 lbs.
Thyroid	Production of these on a commercial scale should be started.
Pituitary	
Insulin	
Estrone	
Progesterone	
Testeosterone	
Stilboestrol	

Liver Extracts.

Injectible	50,000,000 c.cs.
Oral	200,000,000 c.cs.

Insecticides.

Pyrethrum	50,000 tons of dry flowers.
D. D. T.	30,000 tons (dealt with by the heavy chemicals panel).
Paris Green	5,000 tons.

Refrigerating Chemicals.

Freon	400,000 lbs.
Methyl chloride	200,000 lbs.

Photographic Chemicals.

Sodium thiosulphate (hypo)	1,000 tons.
Sodium sulphite	300 tons.
Sodium bisulphite	800 tons.
Pyrogallol	20 tons.
Hydroquinone	50 tons.
Amidol	5 tons.
Metol	20 tons.

Fine Chemicals.

Phenol	250 tons (for drugs alone).
Phenetidine	200 tons.
Phenacetin	50 tons.
Para anisidine	50 tons.
Benzaldehyde	20 tons.
Benzoic acid	20 tons.

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Acetophenone	10 tons.
Resorcinol	25 tons.
Cresols	1,000 tons.
Xylenols	500 tons.
Phthalic anhydride	20 tons (for drugs manufacture).
Phthalic acid	100 tons.
Acetic anhydride	250 tons.
Monochloracetic acid	100 tons.
Citric acid	500 tons.
Lactic acid	100 tons.
Stearic acid	1,000 tons.
Formaldehyde	1,000 tons.
Ethylene oxide	50 tons.
Diethyla mine	50 tons.
Malonic ester	100 tons.
Acetoaceticester	150 tons.
Formicester	100 tons.
Urea	100 tons.
Thiourea	60 tons.
Guanidine nitrate	200 tons.
Glucose	500 tons.
Lactose	750 tons.
Barium peroxide	100 tons.
Phosphoric acid	100 tons.
Phosphorus oxychloride	450 tons.
Thionyl chloride	100 tons.

Solvents.

Alcohol (ethyl)	10,000,000 gallons.
Methyl alcohol	1,200 tons.
Butyl and isobutyl alcohols	500 tons.
Amyl and isoamyl alcohols	500 tons.
Acetone	1,000 tons.
Methyl ethylketene	200 tons.
Ether (ethyl)	250 tons.
Chloroform	500 tons.
Carbon tetrachloride	250 tons.
Tetrachlorethylene	
Acetic acid	1,000 tons.
Ethyl-acetate, Butyl acetate, Amyl acetate	1,500 tons.
enzene	2,000,000 gallons plus about 3,000,000 gallons for production of DDT.).
Toluene	500,000 gallons.
Pyridine (refined 22°)	250 tons.
Nitro benzene	200 tons.
Trichlorethylene	20 tons.
Glycol	1,000 tons.

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Miscellaneous articles.

Metallic Sodium	500 tons.
Activated carbon	250 tons.
Agar	10 tons.
Starch	1,000 tons.

41. DIFFICULTIES HAMPERING THE DEVELOPMENT OF THE MANUFACTURE OF FINE CHEMICALS DRUGS AND PHARMACEUTICALS WITH SUGGESTIONS AS TO HOW TO OVERCOME THESE.—The main difficulties could be stated as follows :—

(*a*) supply of raw materials ;
(*b*) heavy cost of transport ;
(*c*) provincial excise rules ;
(*d*) lack of control over standards of drugs and chemicals ;
(*e*) existing patent laws.

42. *Supply of Raw Materials* :– The raw materials needed for the fine chemicals and drugs industry have already been discussed. As already stated basic chemicals such as, the main acids and alkalies, are available. The prices of these are, however, in many cases too high. With further expansion in the manufacture of these, as is being recommended by the Heavy Chemicals Panel, the prices are likely to come down. The manufacture of increased quantities of intermediates from the distillation products of coal for the preparation of drugs and fine chemicals should be taken in hand immediately. The manufacture of adequate quantities of solvents and of crude vegetable drugs of proper quality should also be organised.

43. *Heavy Cost of Transport.*– The cost of transport of raw material from one part of the country to the other is too high at present. This is an important factor in raising up the cost of production of Indian goods and is responsible for the difficulties experienced by Indian manufacturers in facing competition from abroad. The Railway freights on crude drugs, as in the case of cereals, should be cut down to the minimum.

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44. *Provincial Excise Rules.*– A revision of the provincial excise rules is urgently called for. The manufacturers and distributors are greatly handicapped at present owing to the high price of alcohol and the existence of provincial excise barriers, and of different excise duties in the different provinces. These questions were taken up very strongly by the Drugs Enquiry Committee in 1931. The duty on alcohol, however, still remains high, and the necessary alterations in the Provincial Excise Rules have not yet been effected. On account of the existence of provincial excise restrictions spirituous preparations cannot be transported from one part of the country to the other without overcoming a great deal of vexatious interference. This acts very prejudicially against Indian manufacturers as imported preparations containing alcohol move freely from one part of the country to the other once they had passed the Customs authorities at the Port. In keeping with this, Indian made spirituous preparations should at least be given the same facility of movement from one part of the country to the other as imported spirituous preparations, when once the duty has been paid at the place of manufacture.

45. The Panel on Sugar Alcohol and Food Yeast which has recommended a scheme for a large increase in the production of alcohol also considers that all inter-provincial excise barriers regarding labelling, bottling, etc., of industrial alcohol and spirituous preparations should be abolished and the whole of India should be treated as one unit. A uniform excise policy should be adopted throughout the country and local variations in excise rules should be abolished, as far as possible. The excise duty on spirituous, medicinal and other preparations in all Provinces and States should be uniform. For the manutacture of Fine chemicals and Drugs where Sugar is used as a basic raw material, the present excise duty on sugar should not be levied.

46. *Lack of Control over Standards* :– Although the Drugs Act was passed in 1940, it has not yet been put into operation and there is at present no control over the quality and strength of drugs as sold in the market. Spurious drugs, and alkaloids and biological products below their strengths are now being sold with impunity. This is a very undesirable state of affairs and should end immediately. The Panel, therefore, recommends that the Drugs Act should be immediately brought into force and the provincial governments should take steps to organise Drug Testing Laboratories to implement the Act.

47. A Bill for the introduction of a Pharmacy Act was recently placed by the Government before the Legislative Assembly. Along with the application of the Drugs Act, the Pharmacy Act should be brought into operation, which would make it compulsory for all pharmacies dispensing drugs to employ only qualified compounders, who have received proper training. There should be provision in the rules for ensuring that all medicinal preparations should be accurately dispensed and should contain ingredients of standard purity and strength.

48. *Existing Patent Laws*.– Another very serious hurdle in the development of this industry in the country is the existence of foreign patents covering the process of manufacture of drugs and many essential chemicals. Most of the important processes for making the drugs and chemicals urgently needed for the country are so covered. Sections 22 and 23 of the present Patents Act do seem to provide a theoretical remedy for obtaining compulsory licences from foreign patentees. Licences can be claimed on the plea that " the demand for a patented article is not being met to an adequate extent and on reasonable terms " and that " the patented article or process is manufactured or carried on exclusively or mainly outside India ". In practice it is almost impossible to get a compulsory licence under these sections as they are at present worded. There has not been a single case in India where compulsory licence has been granted under the Patents Act. England was faced with a similar difficulty and the matter was set right by materially altering the Patents Act. These two sections (sections 22 and 23) of the Indian Patents Act require to be modified on the same lines as the British Patents Act. The Controller of Patents should be consulted in this matter and necessary action taken.

49. MENACE OF NON-ETHICAL PATENT AND PROPRIETORY MEDICINES—In the prewar years India used to import proprietory and patent medicines of the value of Rs. 60 to 70 lakhs per annum. On account of the dearth of shipping

space and the manufacturers of patent medicines abroad being engaged in more important work, the import of this class of goods has been reduced to about Rs. 20 lakhs in the year 1943-44. Now that the war is over, Indian market is sure to be flooded again with this class of articles of foreign manufacture. No figures are available as to the indigenous production of patent and proprietory medicine in this country. It has, however, been estimated that, excluding those coming under Ayurvedic and Unani medicines, the total value of these goods produced is not less than half a crore of rupees. If we take into consideration the secret preparations classed under the Ayurvedic and Unani Systems of medicine, the total value of this type of articles from all sources, consumed in this country would run upto about two crores of rupees per annum. Barring a few exceptions, these preparations are entirely worthless. Some of them actually contain ingredients that are positively injurious. Grossly exaggerated claims of efficacy are made for the secret remedies and they cause incalculable injury by leading sick persons to delay in securing proper medical treatment. There is at present no provision at all in this country for the checking of this dangerous trade. The actual loss to the country in money and in health is tromendous. Immediate and drastic steps should be taken to eliminate, as far as possible, this trade in secret drugs which is thriving on the ignorance and credulity of the people.

50. IMPORTANCE OF CONCENTRATING ON THE MANUFACTURE OF SOME ESSENTIAL DRUGS.—It is considered that India should be able gradually to become selfsufficient in her requirements of fine chemicals and drugs. There are, however, certain essential items for which the need is very great and urgent. During the next 5 years it seems specially desirable that we should concentrate our attention on the production of the following articles of vital importance for the health and well-being of the nation :

Vegetable Products ..	Quinine, Pyrethrin, Emetin, Strychnine, Santonin, Ephodrine, Caffeine, Morphine.
Synthetic Chemicals ..	Sulpha Drugs, Mepacrine, Paludrine DDT, Carbarsone, Sulpha-arsphenamine, Nearsphonamine.
Anti-biotics	Penicillin, Strepto-Mycin.
Vitamins :	Vitamin A Vitamin B (complex) Vitamin C.

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(*Vegetable Products.*)—The plants from which the active principles, Quinine Pyrethrin, Emetin, Strychnine, Santonin, Ephedrine, Caffeine, Morphine could be extracted are all now grown in India. In order that the target of production of the drugs, as set out by the Panel, could be reached, it would be necessary in most cases to extend very considerably the cultivation of the plants. The processes of extraction of active principles from the plants are simple in all cases and would present no difficulty. The other requisites would be the availability of adequate quantities of organic solvents such as alcohol, chloroform, ether, acetone, benzene, petroleum ether etc., alkalies such as caustic soda, lime, sodium carbonate and ammonia, acids chiefly sulphuric and hydrochloric. All of these are produced in large quantities in India and the production can be increased as needed. For the production of Quinine 2 million lbs., Emetin 2000 lbs., Strychnine 8,000 lbs., Ephedrine 5,000 lbs., Caffeine 30,000 lbs., and Morphine 3,000 lbs. per annum, it will be necessary to use the following quantities of solvents : 450,000 lbs. of commercial Benzene, 100,000 lbs. of Naphtha, 40,000 lbs. each of Petrol, Chloroform and Ether per annum. In addition, a large quantity of Batching oil will be required for quinine extraction, but the loss of this solvent in the manufacture is practically nil and annual replenishment of the solvent need not be taken into consideration.

51. *Quinine.*—(Target of production 2,000,000 lbs. per annum). About one hundred million cases of malaria occur in the country every year and about 1½ million people per year die of this disease. Most of the deaths and sufferings due to malaria are preventable. Apart from other measures such as adequate nourishment and improved hygienic conditions, the most important requirements in the control and eradication of malaria are the availability of adequate quantities of quinine or other antimalarial drugs and of mosquitocides such as pyrethrin or DDT. The drain on the resources of the country on account of the disability brought about by malaria is tremendous. The efficiency of the people is impaired, the vitality of the nation is markedly lowered and far-reaching economic loss to the country is caused by the wide prevalence of this disease. It has been estimated that over a thousand million working days per year are lost on account of malaria. Even if the value of work of an individual is reckoned as low as /4/- annas per day, the total loss to the country works out to about 25 crores of rupees per annum.

52. The pre-war production of quinine in the country was about 70 thosand pounds per year. Roughly 130 thousand pounds of the alkaloid were imported from abroad. The present production of quinine is about 100 thousand pounds per annum ; there is no import at all at the moment as it is not possible to obtain quinine from countries like Java which supplied India before the war. Calculating on the basis of 100 grains of quinine required for the treatment of a case of malaria and taking into account the quantity needed roughly for prophylactic treatment, India's need for quinine works out at about 2 million pounds per year. The present production of quinine is, therefore, not able to meet even 5 % of the country's need.

53. Cinchona plants are at present grown in the Darjeeling district and in the Nilgiris. There is a vast scope for increase in the cultivation of different varieties of cinchona tree in these areas as well as in other parts of India where the climatic conditions are suitable. It has been estimated that there is enough suitable land in India for the cultivation of cinchona to meet all the needs of the country for quinine and similar alkaloids. There has been considerable discussion as to whether the varieties of cinchona at present cultivated in Government plantations are the most suitable. The Drugs Enquiry Committee of which Sir R. N. Chopra was the Chairman reported that attention had been paid only to the planting of the variety of cinchona yielding quinine.

This variety was too delicate. Sturdier varieties of the plant yielding analogous alkaloids such as quinidine, cinchonine, cinchonidine, which were equally effective as antimalarials should be more suitable for growing in India. Immediate steps should be taken to carefully examine this point and to establish what types of cinchona are the most suitable for growing under Indian conditions and would give the largest recovery of the required alkaloid. The acreage under cinchona should be extended as much as possible without delay. Cinchona plant is comparatively slow in growth and generally takes 6 to 8 years to mature. The Russian method of production of quinine, which considerably shortens the period of cultivation of the plant has to be carefully investigated and, if necessary, the Russian method should be modified to suit the conditions provailing in the country.

54. *Pyrethrin.*—(Target of production 50,000 tons of dried pyrethrum flowers.) In the fight against malaria greatest sucess has been achieved in recent years by the employment of anti-mosquito sprays containing pyrethrin, which has proved remarkably effective in the extermination of mosquitoes which are responsible for spreading malaria.

55. Before the war Japan, which used to produce about 25 million pounds of dried pyrethrum flowers per annum, was almost the sole supplier. Pyrethrum is also grown in large quantities in the highlands of Kenya, East Africa. Pyrethrin sprays and anti-mosquito creams containing pyrethrin have given remarkable protection against malaria to the men engaged in fighting in malaria infested jungle areas. There has been great shortage of pyrethrum from the commencement of hostilities against Japan. Kenya, which became the only source of supply for the allied nations was not able to meet all the requirements. The Government of India took active steps to import seeds from Kenya and encourage plantations in suitable mountaineous regions in Kashmir, Madras and the Punjab. Recently, Pyrethrum has also been grown in the Khasi Hills in Assam and in Mysore. The efforts in growing pyrethrum in all these areas have been successful but so far cultivation has only been on a small scale.

56. The chemical and technical problems connected with the extraction of pyrethrin from pyrethrum are simple. The most urgent need is the rapid extension of areas under cultivation. The requirements of the country are very large and have been estimated at about 50,000 tons of dried pyrethrum flowers per annum. It will require very careful planning and intensive efforts to produce the required quantity of the flower. Immediate steps will have to be taken to make a complete survey of the areas suitable for the cultivation of pyrethrum and arrangements have to be made to collect the right variety of seed and start plantation in these areas. A commercial company has recently been floated with an authorised capital of 25 lakhs of rupees to acquire some pyrethrum estates in the Khasi hills and to exploit production of pyrothrin. It seems advisable that such commercial ventures should be encouraged, although it will be necessary to exercise control so that the products manufactured are up to a definite specified standard.

57. *Emetin.*—(Target of production 2,000 lbs. per annum.) The alkaloid emetin is the active principle derived from Ipecacuanha root. Ipecac plant is not native of India, but attempt has been made by the Government since 1916 to introduce the cultivation of this plant. In the Darjeeling District and in

the Nilgiris the plant has been growing successfully. A five year plan for the expansion of the cultivation of Ipecac has been undertaken by the Bengal Government. This is not adequate to meet the entire requirements of the country. Medical surveys have estiblished that there is a very wide prevalence of amoebic dysentery in this country. It has been estimated that as many as 10% of the population *i.e.*, about 40 million people suffer from amœbic infections. Emetin is a very effective destructive agent against amœba and has proved to be of greatest value in the treatment of amoebic dysentery.

58. The present production of ipecac roots is about 1500 lbs. per annum. This is able to yield about 18—19 lbs. of emetin which is enough for the treatment of about 25 thousand cases. Actually emetin is not commercially manufactured at all in the country. It has been prepared in the laboratory, but commercial production of the drug has not been started yet. Practically the whole of emetin used is imported from abroad and it is only put in ampoules and containers by the drug manufacturing firms. If ipecacuanha is available in adequate quantities there is no doubt that it will be possible to manufacture emetin in the country, as there is no special technical difficulty in its preparation from ipecacuanha roots.

59. It is essential that the cultivation of ipecac should be greatly increased at a very early date. The plant takes about three years to mature. For the treatment of 2½ million people about 15 million grains or approximately 2150 lbs. of emetin is necessary. On the basis of recovery of 1·25 lbs. of emetin from 100 lbs. of the root this will require the production of about 172,000 pounds of ipecacuanha root and will mean over 100 fold extension of the present cultivation of ipecac. It is believed by competent authorities that there are vast areas in this country suitable for the cultivation of ipecac and that the required quantity of the plant could be grown. Careful planning of the areas in which the plant could be grown should be prepared and immediate action taken to implement the plan of expanding the cultivation of ipecac on an extensive scale. The suffering of the people and the economic loss to the country on account of the prevalence of amoebic infections is very large. At least 200 million working days are lost every year resulting in a loss of 5 crores of rupees at the lowest computation.

60. *Strychnine*.—(Target of production 16,000 lbs. per annum). Strychnine is obtained from Nux-Vomica seeds. The average yield of strychnine is about 1·5%. About 1,060,000 lbs. of Nux Vomica seeds per annum will thus be required for the production of 16,000 lbs. of Strychnine.

61. Nux Vomica is chiefly grown in Orissa. Its cultivation could, however, be developed in other parts of India. The present production of strychnine in the country is nearly 15,000 lbs. per annum. It is chiefly exported to Australia for destruction of wild rabbits. The domestic consumption is only about 200 pounds. Export of strychnine in pre-war years was controlled by the international strychnine cartel which operated from outside India. The export quota allotted to India before the war was very limited. The quality of strychnine produced in India has been good ; hence the arbitrary fixation of low quota from abroad should be resisted. Transport charges of Nux-Vomica seeds are at present too high :these should be lowered.

62. *Santonin.*—(Target of production 3,000 lbs. per annum.) Santonin is produced from Artomesia, cultivation of which in Kashmir has been successful.

On account of widespread prevalence of helminthic infections there is great need for santonin in India. There is also a considerable export demand. The quality of santonin produced in India from artemesia has been good. Present production is about 2 to 3 thousand pounds per annum.

63. *Ephedrine.*—(Target of production 5,000 lbs. per annum.) Ephedrine is prepared from a species of Ephedra herb indigenous to this country. The alkaloid contained in the herb varies from 0·5 to 1%. Taking the approximate average yield of 0·75% of Ephedrine, the annual requirement of Ephedra herb for the production of 5,000 lbs. Ephedrine will be about 670,000 lbs. India now produces about 3,000 lbs. of Ephedrine per annum. The quality of Indian Ephedrine has been satisfactory.

64. *Caffeine.*— (Target of production 30,000 lbs. per annum.) Caffeine is prepared from Tea waste available in very large quantities in this country. Taking an average yield of about 2% caffeine from tea waste, the quantity of the latter required for the production of 30,000 lbs. of caffeine will be 1,500,000 lbs.

65. A large quantity of tea dust used to be exported from India before the war. At present about 20 thousand pounds of caffeine are produced in India from tea dust. The quality of caffeine is satisfactory. A factory for the preparation of crude caffeine has now been set up in the tea gardens area in Assam. The crude product is refined in Calcutta.

66. *Morphine & Codeine (targets of production : morphine 3000 lbs. per annum ; Codeine 1500 lbs. per annum).*— Opium alkoloids are produced in India only at the Government Alkaloid Works, Ghazipur, and issues therefrom are made on the production of Provincial Excise permits to be obtained by the purchasers to meet their legitimate requirements.

Before the second World War, the average (1935-39) production of morphine and its salts at the Alkaloid Works, Ghazipur, was 1,100 lbs. and that of codeine and its salts 200 lbs. per annum. During the war, the demand for the opium alkaloids very greatly increased from the trade and the Government both for civil and military purposes. It was also decided to meet the war demands of the Eastern Group countries. Although the production of morphine was nearly doubled at Ghazipur and the quantity of codeine produced in 1943 was 424 lbs. (the average production of codeine during the war years 1940-44 *viz.* 207 lbs. did not however show any appreciable increase over the pre-war years production) there was much difficulty in meeting the trade demands and the pharmaceutical concerns in the country making preparations containing morphine and codeine could not for some time obtain the required quantities of opium alkaloids from the Alkaloid Works, Ghazipur.

As a result of the difficulty experienced by the Alkaloid Works, Ghazipur in meeting the abnormal demands, it was decided to expand the alkaloid manufacturing section in 1941. A new plant was accordingly ordered and installed which, however, due to various unavoidable factors, could not work in full swing until the present year *i.e.* till after the end of the war. As a consequence, the plant did not fulfil its original purpose of supplying India's war-time needs of opium alkaloids. Its potential output is 8,000 lbs. per annum which is more than ample for peace-time requirements and it is hoped that the pharmaceutical trade will have no difficulty hereafter in obtaining the requisite quantities. At present owing to low demands, full capacity of the plant is not being utilised.

The Panel recommends that Morphine may be released more liberally to firms of repute in the country engaged in the manufacture of ethical pharmaceutical preparations.

A note by Mr. M. B. Amin on ' Galenicals and Alkaloids ' and a supplementary note by Mr. Adhikari may be seen in Appendices 1(*a*) and 1(*b*).

67. *Synthetic Chemicals.*— Treatment of diseases has for a long time been purely symptomatic. In recent years however advance in the Science of Synthetic Chemistry has placed very specific chemicals for treatment of infectious diseases. One of the most important advances in this direction has been the discovery of Sulpha drugs, and anti-malarials like Atebrine (Mepacrine). These Synthetic drugs alone with anti-biotics, like penicillin and streptomycine can combat 3/4ths of all major illnesses that occur in the country. These drugs thus constitute the most important group of drugs available for treatment of disease and must receive the most earnest attention.

68. *Sulpha drugs* :—One of the most important advances in medical science in recent years in the treatment of infectious diseases has been the introduction of sulphanilamide and related drugs in the treatment of infective conditions. Sulphanilamide was first synthesised in 1908 and had been used in the preparation of dyestuffs. In 1935 in the course of a study of the anti-bacterial activity of a group of azo dyes derived from p-aminobenzenesulphonamide it was discovered that the effectiveness resided in the sulphonamide part of the molecule. This happy observation on the part of French investigators led to the adoption of sulphanilamide in medicine. Unlike other bactericidal compounds which cannot be used internally on account of their poisonous effects on the human body sulphanilamide and its derivatives could be taken internally for the purpose of destroying the invading bacteria without the production of severe toxic symptoms in the patient.

The discovery of Sulpha drugs has provided medical men with an instrument of inestimable value in the fight against bacterial diseases. In the treatment of some of the deadly epidemic diseases which rage in India the drugs have proved extremely useful. It is essential that Sulpha drugs should be produced in the country on a large scale and made available at the lowest possible cost for the treatment of the poor.

69. Thousands of derivatives of sulphanilamide have been produced in recent years but the most important are the following, the production of which should be undertaken on a large scale in the country as indicated below :—

Sulphanilamide	100,000 lbs. per annum.
Sulphathiazole	1000.000 ,, ,, ,,
Sulphadiazine	150,000 ,, ,, ,,
Sulphamethazine	100,000 ,, ,, ,,
Sulphaphthalidine	50,000 ,, ,, ,,

A note on the manufacture of Sulpha drugs in India by Dr. Ganapati and Sir S. S. Sokhey may be seen in appendix II. In it the chemicals and equipments required for the manufacture of 500,000 lbs. of Sulpha drugs per annum have been stated and the immediate steps necessary for producing the drug have been outlined.

70. *Mepacrine.*—(Target of production 160,000 lbs. per annum.) In recent years synthetic chemistry has provided us with certain drugs which could act as substitutes for quinine in combating malaria. The most important of these is mepacrine. Calculating on the basis of about 25 grains of mepacrine required for the treatment of each case of malaria, about 350 thousand pounds of mepacrine will be needed for the treatment of 100 million cases. As a partial substitute for quinine it should be our aim to produce 160 thousand pounds of this drug per annum. The great advantage with mepacrine is that it is prepared synthetically and its production is not limited by such factors as delay in plantation and slow growth of plants as in the case of quinine.

71. The synthetic production of mepacrine is rather complicated. It is synthesised from several components, some of which are readily available in the country whilst others are at present not produced and have to be imported. Small quantities of the drug have already been prepared in the Haffkine Institute, Bombay, and by some of the commercial firms. Energetic measures will have to be taken for greatly increased production of mepacrine. The chemicals needed for its preparation should as far as possible be made in the country, though at the beginning it may be necessary to import some of these from abroad. A note by Dr. K. Ganapati and Sir S. S. Sokhey on the manufacture of mepacrine may be seen in appendix III. In it a scheme for the preparation of 500,000 lbs. of the drug per annum has been outlined. The chemicals and equipments needed and their quantities have been stated and the measures required to attain the required production of the drug have been indicated.

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In recent months very great success has been claimed in the treatment of Malaria by the use of new synthetic drugs such as Paludrine and S. N. 7618 (7-chloro-4-diethylamine-methylamine butyl quinoline). Steps should also be taken to manufacture these drugs in India.

72. *DDT.*—(Target of production 30,000 tons per annum.) DDT is an abbreviation of the name of the chemical compound-pp' dichloro-diphenyl-WW'W " trichloroethane. It was synthesised as early as 1874, but its remarkable properties as an insecticide were not discovered till the World War II called for an effective insecticide. The important feature of this insecticide is its persistent action by virtue of which it remains effective over an unusually long period of time unattained by any other insecticide so far developed. For spraying over fields and marshy lands DDT has thus proved exceedingly useful. DDT is effective in low dilution. It is used both in sprays and in the preparation of dusting powders. The manufacture of DDT does not present a difficult chemical problem. Several firms have produced the article on a small scale. What is of vital importance is that the raw materials Benzene, chlorine and alcohol required for its production should be available, cheaply and in sufficient quantities.

73. It will be necessary to increase the production of benzene from the distillation of coal and increase the production of chlorine. The Panel on Sugar, Alcohol etc., has already recommended a very large increase in the production of absolute alcohol. When these three substances are available in required quantities it should be possible for India to be self-sufficient in her requirements of DDT. Efforts for the production of DDT should go hand in hand with arrangements for the rapid extension of acreage under pyrethrum. DDT and pyrethrum would be invaluable, not only in the destruction of malaria carrying mosquitoes, but will be of tremendous help in the eradication of innumerable insect pests with which the country is infested.

74. *p-Carbaminophenyl Arsonic Acid* (*carbarsone*).—(Target of production—25 million grammes per annum.) Side by side with the measures for the increase in the cultivation of ipecac for the manufacture of emetin, steps should be taken to increase the production of p-carbaminophenyl Arsonic Acid. This synthetic organometallic compound has been found extremely effective in the treatment of amoebic dysentery. This drug is produced in India, but the total production at present is only about a million grammes per annum. This is enough for the treatment of about 2 lakh cases. Considering that there are about 40 million sufferers in this country of varieties of disorders brought about by amoebic infection, the quantity of carbarsone produced at present is highly inadequate. If we aim at treating 5 million cases with this drug it will be necessary to increase our present production 25 times.

75. The most important raw materials needed for the preparation of p-carbaminophenyl Arsonic Acid are arsenic and aniline. The production of aniline, which is also required for the manufacture of sulpha drugs, mepacrine and various other substances, must be increased markedly at an early date. Efforts should also be directed to the location of a suitable indigenous source of arsenic. At present there is a definite shortage of this commodity and it may be necessary to have recourse to the importation of arsenic from abroad at the beginning. The panel recommends that necessary steps should be taken to increase the production of quinoline derivatives such as chiniofonum, di-iodoquin etc, which have been fonnd effective in the treatment of amoebic infections already these are being manufactured on a small scale.

76. *Sulpharsphenamine and Neo-arsphenamine* : (Target of production 25 million grammes per annum.) It is considered that for a considerable time to come the demand for these well-tried arsenical preparations will remain high and a production of 25 million grammes per annum of these drugs in the country should be achieved. The main difficulty in this regard will be same as in the preparation of Carbarsene, namely the availability of arsenic. This will have to be imported from abroad till suitable indigenous source of arsenic could be found.

77. *Anti-Biotics*.—Penicillin and Streptomycin are amongst the most important drugs in the treatment of bacterial infections. They more or less cover the same field as the sulpha drugs. So the question arises whether the antibiotics would completely displace the sulpha drugs. The answer is definite.

From the therapeutic point of view, Penicillin is an effective supplement, but not a substitute for the sulpha drugs. The modes of action of these two classes of drugs are dissimilar and their spectra of therapeutic activity are not exactly the same though they overlap in certain regions. Actually, in the anti-biotics we are ordinarily looking to cover the regions where the Sulpha drugs are of no use. Further the Sulpha drugs, unlike Penicillin and other biological products are very stable, and can be stored almost indefinitely. Because of this property, sulpha drugs will be the drugs of choice for use in the rural areas of India. The use of Penicillin will be limited for long to urban areas.

78. *Penicillin.*—(Target of production one million million units per annum.) Penicillin is effective against a number of deadly bacteria resistant to sulphonamides. Unlike sulphonamides its antibacterial action is in no way diminished by blood, pus, and tissue fluids. Its chief value lies in the fact that it is absolutely non-toxic to human tissues, even at high concentrations, while its inhibitary action is exerted in extremely dilute solutions.

79. It has not yet been possible to prepare penicillin synthetically. The only known way in which it is produced at present is by the activity of a mould belonging to the species of penicillium. The chief difficulty connected with its manufacture is that the mould is capable of producing it only in infinitesimal quantities. From the culture medium, penicillin has to be concentrated nearly a hundred thousand times for preparing it in a form suitable for injections. The unstable nature of penicillin towards heat, acids, alkalies, heavy metals and many common laboratory re-agents, makes its production extremely complicated. There are two methods of production of penicillin which are commercially practised. The first is the surface culture method, where the mould is grown in shallow layers of nutrient media in bottles ; the second is the submerged culture method where the growth takes place in huge vessels of liquid media. The second method is now generally employed for large scale production of penicillin, as it is far more economical in labour and in material. Large deep tanks are used as fermenters which have to be kept under a septic condition. The sterility of the media should be absolute. Even a few stray bacteria left in are enough to spoil the broth. A very large volume of absolutely sterile air has to be delivered to the fermenters for the mould to respire.

80. The difficulties of manufacture of penicillin have now been gradually conquered and large quantities of the drug are being produced in U.K., U.S.A. and Canada. The production of penicillin in U.S.A has increased from 425 million units per month in June 1943 to 460,000 million units per month in March 1945. With this thousand fold increase in the production of penicillin, the cost of manufacture has also been brought down considerably. In the two years between 1943 and 1945 the price of penicillin has dropped from $20 to less than $2 per 100,000 units. A note by Dr. K. Ganapati and Sir S. S. Sokhey may be seen in Appendix IV ; in it the chemicals and equipments necessary and the measures required for effecting large scale production of penicillin have been described.

81. The need for penicillin in India is very great and it is essential to start its production on a very large scale. The cost of production should be the lowest possible and no profit motive should enter into the scheme. The

Panel recommends that the production should be undertaken at first as a State enterprise. The same remarks apply to sulpha drugs and mepacrine. All these three vitally important groups of drugs should be manufactured under the control and management of the State. Qualified scientists should be sent abroad to get acquainted with the latest techniques of manufacture and the production should be taken in hand at the earliest possible date.

82. *Vitamins.*—They are present in natural food and a well balanced diet should provide all the necessary vitamins. A wide variety of food-stuffs such as green leafy vegetables, fruits and milk are essential features of a well balanced diet. Widespread malnutrition prevails in the country at present because of lack of both quantity and the right quality of food. While the problem of increasing the quantity of food available to the people is at present receiving serious attention of the Government, the production of vitamins should be taken in hand to combat the qualitative deficiency in the diet of the people. In addition vitamins are used as drugs in the treatment of diseases.

83. *Vitamins D, E and K.*—Vitamins E and K are present widely in different articles consumed as food. So there is little likelihood of shortage of these vitamins. Vitamin D is formed naturally by the action of sunlight on the skin. In a country such as India where there is no dearth of sunshine the danger of deficiency of vitamin D is not very great except in such persons, who on account of social customs or habits spend the whole of their time indoors, shut away from the light. Hence, the production mainly of vitamins A, C and vitamins of B group need be considered here, but a certain quantity of vitamin D (calciferol) should also be produced in the country. We understand that the Technical and Planning Panels of the Food Department are considering this question.

84. *Vitamin A.*—(Target of production 1,000,000 gallons of shark liver oil of potency 6,000 units per gramme) Shark-liver oil industry has assumed great importance in recent years. Shark-liver oil is a very rich source of vitamin A. So far, the medical world has depended on cod-liver oil, but shark-liver oil is much richer in its content of vitamin A than cod-liver oil. Good samples of shark-liver oil are, on an average, 10 times as potent as cod-liver oil. Some samples are even 100 times as potent. Indian waters abound in shark. There is thus a basis for a valuable industry of the greatest importance to the country.

85. Vitamin A is one of the most important vitamins and it plays a significant role in the nutrition of the children and adults. Deficiency of this vitamin retards growth, causes night blindness, and lowers the general resistance towards infection. If children do not get adequate quantities of it, they remain ill-developed.

86. Normally, children and adults the world over get their requirements of vitamin A from milk. But milk is scarce in India with the result that Indian manhood is ill-developed. This, coupled with the critical food situation prevailing in the country, is leading to a great deal of sickness and ill-health. In countries like America where milk is plentiful, the stature of

the European populations that have migrated to America has shown a significant increase in height. In India the trend is in the reverse direction because of the inadequate quantities of milk available to the people. This grave shortage can be ameliorated to a certain extent, in so far as vitamin A is concerned, by making available plentiful supplies of shark liver oil.

87. At present the industry is very haphazardly organized. The Fisheries Departments of some maritime provinces and some private agencies are engaged in the production of shark-liver oil. But no one, as far as we know is conducting the fishing of shark or the extraction of oil on any scientific basis. Fishing is usually done indiscriminately by fishermen with the means at their disposal which are not adequate for the purpose. Extraction of the oil is done under quite primitive conditions and the oil loses a considerable amount of its potency and acquires a very unpleasant taste and odour. The panel feels that urgent steps should be taken to put the industry on a better basis. First the fishing should be properly organised under the scientific control of the various Fisheries Departments and secondly for the processing of livers suitable factories, equipped with modern appliances, should be provided.

88. Though the need of the country is great, there are no adequate organisations for making the oil available to the people who need it, and although the amount of oil produced at present is far below the country's actual needs yet even the small amounts of oil that are being produced are not finding a market. The Fisheries Departments have actually been forced to curtail production. Coupled with this is the uncontrolled sale of spurious shark-liver oil products by private agencies. Shark-liver oil is a new product and if people, by using spurious preparations, come to form an opinion that shark-liver oil is not as good as cod-liver oil, the industry would be damaged beyond repair.

89. To remedy the situation, three steps require to be taken almost immediately. First the work of the Fisheries Departments of the various Governments should be co-ordinated to put the fishing of sharks and the production of oil on sound scientific lines. Secondly, the Food Departments of the various Governments should make available to the people, either free or at a nominal cost, this most important source of vitamin A. A great deal of propaganda may be necessary to get people used to this product. Thirdly, the Drugs Act should be brought into force, as soon as possible to prevent the manufacture and sale of spurious products.

90. With this object in view, the panel adopted the following resolution :—

" In view of the extreme importance of vitamin " A " in the nutrition of the people, the demonstrated lack of it in the diet of the vast majority of the people of India causing extensive ill-health and the need of its being fed as a routine measure, particularly to the vulnerable groups of the population, the Panel recommends that the Government of India do set up as early as possible a Central Board representing the relevant Departments of the Government of India, the Departments of Fisheries of the different maritime Provinces and non-official experts. This Board should be advisory in capacity. It should be provided with a whole-time Secretary and should work out the necessary steps to put the shark-liver oil industry on a sound and permanent basis. The Board will devise methods for bringing into being suitable arrangements for the proper methods of fishing to secure adequate supply of fish for the country ; will study and fix seasons during which fishing should be carried out to safeguard the proper breeding of the fish ; will study, devise methods for bringing into being suitable processes for the extraction of oil and utilisation of by-products ; will suggest setting up of plants for the extraction of vitamin ' A ' from the oil ; will suggest standards ; will suggest the formation of a Marketing Board and devise ways and means for making available to the people oil of standard quality and vitamin ' A ' concentrates. The Board will also recommend means for securing adequate standard of wages for workers in the industry which will secure their general well-being ".

91. We understand that the Technical and Planning Panels of the Food Department are considering the targets of production of Vitamin A concentrates and planning for their production. In this connection reference may be made to Appendices VI and VII where the question of manufacture and use of shark liver oil and Vitamin A concentrates has been discussed.

92. *Vitamin B (complex)* consists of several vitamins ; vitamin B1 or thiamin, vitamin B2 or riboflavin, nicotinic acid, etc. The deficiency of this vitamin is most common in Indian dietary. This is chiefly due to the dependence of the Indian people on cereals such as rice, which is highly polished, and wheat, which is highly milled, and the absence of articles such as meat, milk, egg-yolk, green vegetables etc., in the diet. One method of meeting this deficiency of vitamin B would be to introduce yeast in the dietary. Yeast is a cheap and concentrated form of vitamin B (complex) as well as of high class protein. The Food Department is giving special consideration to the question of large scale production of yeast in the country. The production of pure vitamins of B group, particularly thiamin, riboflavin and nicotinic acid, should be undertaken. We understand that the Technical and Planning Panels of the Food Department are fixing targets for these vitamins and planning for their production. We would recommend that such plans of production should be integrated with the schemes of production of fine-chemicals.

93. *Vitamin C.*—Vitamin C is present in fresh citrous fruits such as oranges, lemons, other fresh fruits and fresh vegetables. Gross deficiency of this vitamin leads to scurvy, but partial deficiency leads to ill-health and lower resistence to diseases. Dried Amla powder has been used in this country as a source of Vitamin C. Ascorbic acid or vitamin C is, however, now made synthetically in most countries. The synthetic preparation of this article is not chemically difficult and it could be made in this country. The need of vitamin C for an adult is about 75 milligrammes per day. Gross deficiency of this vitamin is not so common in this country as that of vitamins A and B, but a large section of the population suffers from partial deprivation of this vitamin. The needs of about 2 million people for a daily supplement of 25 milligramme of vitamin C could be provided by the production of roughly 100 lbs. of ascorbic acid per day. We understand that the Technical and Planning Panels of the Food

Department are fixing targets for the production of this vitamin and we recommend that the plan of production should be integrated with the plan of production of fine chemicals.

94. FINE CHEMICALS AND SOLVENTS—The development of the manufacture of fine chemicals and solvents on a large scale in the country is absolutely essential for the establishment of the drugs and pharmaceutical industries as well as for the plastics, rubber and other industries. So far very little progress has been made in this direction. The fine chemicals industry is dependent on the development of the heavy chemical industry and the availability of adequate quantities of basic and intermediate chemicals and solvents. The suggestions of the Panel regarding the targets of production of different Fine Chemicals and Solvents are given in paragraph 40. During the war, two large Government plants for the manufacture of Benzene have been set up at Jamshedpur and Hirapur. When the projects for the contemplated large increase in the production of steel are put into operation it will be possible to set up similar large plants for the increased manufacture of Benzene to meet the rapidly growing needs of the drugs, fine chemicals and other industries for Benzene. The Panel on Sugar, Alcohol and Food Yeast has recommended production of very large quantities of absolute alcohol in the country. With the introduction of the scheme, it is believed cheap alcohol would be available to the fine chemicals industry. Two notes by Dr. J. N. Ray on fine chemicals and solvents may be seen in appendices VIII and IX. The developments of the heavy chemical industry, dye industry and the fine chemical and drug industry must necessarily go together and more and more of these should be manufactured until the country becomes self-sufficient in all these fields. Materials and talents are available in the country. What is needed is a well integrated plan executed with vigour. The fine chemicals industry in India to-day suffers from lack of equipments. The chief chemicals operations involved in the preparation of fine chemicals are not many and known to the existing manufacturers. There are however some important respects in which Indian manufacturers have not been up to the modern practices obtained abroad viz., in the application of electro-chemical and high pressure technique. In these important respects the deficiency of India will have to be made good.

95. PHOTOGRAPHIC CHEMICALS—The only photographic chemicals manufactured in appreciable quantities in India at present are Sodium Hypo Sulphite (Hypo), Sodium Sulphite and Sodium bi-sulphite.

The present annual production capacities for the chemicals are roughly as follows :

Hypo	.. 900 tons.
Sodium Sulphite ..	.. 300 tons.
Sodium bi-sulphite ..	.. 300 tons.

The present requirements in India per annum are about 500 to 600 tons Hypo, 150 tons Sodium Sulphite and 400 to 500 tons Sodium Bi-Sulphite. 80% of these chemicals is used by the film industry. It is believed that the demand would increase by 100% within the next 10 years.

96. There is a considerable demand also for Chrome Alum—about 700 to 800 tons per annum. Some amount of Chrome Alum is now being produced in Bombay. There is no production at all of developing agents such as Hydroquinone, Rhodinel etc. The weakness of the Indian Industry in photographic chemicals lies in this. Production of developers should be started in this country. The targets of production of photographic chemicals are given in paragraph 40.

97. EQUIPMENT AND MACHINERY.—Lack of proper equipments and machinery has been a great handicap in the development of the industry. For the large scale production of fine chemicals and drugs, it is necessary to have in the country engineering firms capable of making modern plants and appliances. Due to the high standard of purity required in the manufacture of drugs and fine chemicals, corrosion resistant vessels have to be employed in a great number of operations. These vessels should be acid and alkali resistant and consist of enamelled, porcelain, glass and rubber lined stills, kettles and pots, or vessels made of stainless steel, monel, inconel, etc. None of these are now made in India. While attempts should be made to manufacture special alloys such as stainless steel, monel, inconel, etc., and for making enamelled, glass and rubber lined vessels in the country, it will be necessary to import these materials from abroad for some time, in order not to hold up the expansion of the fine chemicals and drugs industry.

98. Many of the processes involved in the manufacture of fine chemicals and drugs represent but a large scale laboratory experiment and large glass flasks, retorts, condensers etc., are employed. Glass apparatus of all kinds and equipments such as percolators, concentration pans, filter presses, centrifugals, distillation columns, incubators, ovens and simple autoclaves have been fabricated in the country in small quantities under proper supervision. There is however, no firm in India at present capable of executing large orders for such equipments. It will take some time for the manufacture of machinery and equipments of all kinds to be developed on a large scale, so the supply is likely to lag behind the demand. In order to stimulate the development of the manufacture of fine chemicals and drugs, it will be necessary in the beginning to import equipments that are urgently required. At the same time, efforts should, of course, be made to develop the production of machinery in this country. Two notes by Mr. N. Adhikari on the subject of machinery and equipments may be seen in Appendices XI (*a*) and XI (*b*).

99. GENERAL QUESTIONS OF POLICY—In the opinion of the Panel India should attain self-sufficiency with regard to fine chemicals, drugs and pharmaceuticals within the next 15 years. In order to achieve this, it will be necessary to expand the coal distillation industry. India at present has a production capacity of about two million gallons of Benzene and half a million gallons of Toluene per annum. It is necessary that the plants producing Benzene and Toluene should be kept in full operation. With the large amount of Bonzene and Toluene available, it will be possible to produce such intermediates as Phenol, Aniline etc., which would form a suitable starting point for the manufacture of fine chemicals, synthetic

and allied products. We presume that the Panel on Heavy Chemicals has considered the desirability of making the heavy chemicals required for the development of the industry available to the manufacturers at a reasonable price.

100. *Management of Industry.*—Large quantities of Benzene and Toluene are being produced in Government plants. This production should be continued and further extend-ed. It is also absolutely necessary that the production of coal tar intermediates should be developed. At the present moment no firms are producing these in India. The State should initiate the production of these themselves and/or through private enterprise if possible. Many industries are handicapped at the present moment, because of the non-availability of aniline, phenol, chloro-benzene, etc. It is necessary that these should be made easily and cheaply available, if our targets of production of various drugs and chemicals are to fructify. In the case of the manufacture of new and vitally important drugs such as Penicillin, streptomycine, mepacrine, sulpha drugs etc., the State should take the initiative and should take up production and at least put up the first plants to serve as models and to train up personnel. As regards other products we are dealing, in view of what we state in paras. below, we are not in a position to indicate here what type of management should be employed for their production, which will depend on the decision taken on all the different fields.

101. *State Aids.*—The State should take up initiative with a view to help industry and set up pilot plants where necessary. Production should be started wherever necessary with imported basic and intermediate materials.

102. The Nascent industries will have to be protected. The exact method by which this can be achieved would depend on the industry concerned.

103. Research on fundamental problems connected with the manufacture of fine chemicals, drugs and pharmaceuticals in the country should be liberally subsidized by the Government. Certain experts may have to be provided by the Government to advise industries on specific problems connected with the production.

104. *Training of technical personnel.*—The training of scientific and technical personnel for the development of industry is a subject that should have our closest attention. We have paid considerable attention to this and are of the opinion that we must first decide on the projects we want to undertake in the country. We should then look for the likely men in the country who can undertake that work either because they are actually engaged in it or have the basic training which would be of value for carrying through that project. Such men should be formed into teams and each one allotted a specific place in the development of that project. Once such teams are formed we may even start developing the project itself and in the working of it we may find that the men need training abroad to fill gaps in their existing knowledge and experience. They will then go abroad with specific duties in the project allotted to them and they will thus be studying preselected problems, to enable them to competently take part in the work of the team. Such training will have meaning and purpose. The present practice of sending individuals abroad for

studying wide subjects cannot yield any practical results. The full value of training can be derived only if well-trained men are sent abroad to specialise in specifically selected portions of a project. Thus a number of men would complement one another's knowledge and make a well-trained team to cover the whole project. The government should arrange that suitably qualified university graduates may receive practical training in the manufacture of fine chemicals and pharmaceuticals in the manufacturing concerns in India.

105. *Foreign capital.*—While the Panel considers that it will be preferable to be independent of foreign capital and management, it is felt that this question will have to be considered on the merits of each case. Where it is necessary to depart from this principle, certain measures for safeguarding the interests of the country should be adopted.

106. *Location of Industry.*—In the opinion of the Panel, the industries should be located primarily on the consideration of availability of raw materials, labour, consumption and distribution facilities in relation to other industries.

107 *Association of Industries*—It is felt that associations of industries would be of considerable help in the development of new industries, but in the opinion of the Panel cartels are definitely undesirable. Every encouragement should be given for the expansion of each group of industries.

108. *Customs Duty.*—The Customs duty on raw-materials and semi-manufactured goods required for the industry should be remitted for the first 5 years and the duty on finished materials should be increased gradually as soon as manufacture begins to develop. Capital goods* required for the industry should be allowed to be imported free of duty for the first ten years.

109. *Railway Freights.*—The present railway freights on raw material and finished goods are extremely high and act as deterrent to the development of the Fine Chemicals and Drugs Industry. The Railway rates should be revised and brought down.

110. *Excise Policy.*—A uniform excise policy should be adopted throughout the country and local variations in excise rates should be abolished. The excise duty on spirituous, medicinal and other preparations in all Provinces and States should be uniform. Indian made spirituous preparations should have the same facility of movement from one part of the country to another as imported spirituous preparations, when once the duty has been paid at the place of manufacture.

For the manufacture of fine chemicals and drugs where sugar is used as a basic raw material, the present excise duty on sugar should not be levied.

111. *Export.*—There is definitely scope for export and attempts should be made to make full use of the export markets. Exports should be encouraged without any prejudice to the needs and interests of the country.

112. *Suggestions as to the stages by which the fine Chemicals and Drugs Industry is to be developed.*—We should have liked to have been in a position to indicate a programme for the development of the fine chemicals and drugs industry in the country.

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* Plants, machinery, laboratory apparatus, etc., as required by the Fine Chemicals and Pharmaceuticals Industry.

The proper development of this industry, leading to self-sufficiency, requires a well-balanced and integrated plan for the production of heavy chemicals, coal distillation products, organic solvents (produced by fermentation and synthetic processes) and the intermediates manufactured from the former. Then again, the production of these starting materials has to be linked up not only with the needs of the drugs and fine chemicals industry but also with those of the dye-stuff, artificial fibre, plastic and synthetic rubber industries and production of Vitamins as suggested by the Technical and Planning Panels of the Food Department, which also require many of the same basic materials. A programme of production, thus, can be drawn up only by integrating the reports of the panels dealing with the planning and production of the above-mentioned raw materials and finished products. This panel is not in a position to draw up the needed programme in a very concrete way. The Panel recommends that the Government should now set up a Technical Planning commission to prepare concrete and detailed plans for the development of each of these industries and finding ways and means of implementing these plans.

113. We should, however, like to discuss here an equally important question regarding drugs and fine chemicals manufacture, whether the production of the raw materials or the drugs should be taken up first. It is often suggested that we should begin with the production of basic materials and make the country self-sufficient in them before we take up the manufacture of drugs and fine chemicals. A moment's reflection will, however, tell that to defer undertaking the manufacture of the drugs until the production of the basic chemicals has been established in the country is not a practical proposition. The manufacture of basic materials and drugs must go side by side. The production of some basic chemicals can be taken up immediately, while that of others has to wait on the development of resources. In the very nature of things, it will take a considerable time before the country becomes self-sufficient in all the basic materials. The practical way to establish the industry is to decide upon the minimum number of drugs and fine chemicals essential for the country. We should start with the production of these drugs, utilising the raw materials already available in the country and importing others not so available. This will have two desirable effects. First, this procedure will provide the country with a supply of the essential drugs from the very start and at prices which will compare favourably with those of the imported drugs. Secondly, this is equally important, it will create a demand for the basic chemicals and thus give an impetus to their production in the country. As the production of the essential drugs and fine chemicals proceeds, we should be developing the manufacture of the basic materials required. We should aim at self-sufficiency in a period of 15 years both as regards the raw chemicals and finished products. Therefore, we definitely suggest that the production of essential drugs should not wait on the production of basic chemicals in the country, but we should start with the manufacture of essential drugs and import the raw materials not available here till we develop our resources.

114. Consonant with the policy indicated above, the manufacture of two types of drugs should be taken up immediately, namely (1) those which are essential for guarding the health of the public and warding off infectious diseases

and (2) those for which India already has, or can easily develop, raw materials in abundance. Under the first category come the sulpha drugs, antimalarials (quinine, mepacrine and pamaquine), penicillin and streptomycin. The arsenicals and D.D.T. can also be included in this list. The manufacture of these drugs should be taken up immediately. The Panel recommends that Government should take up the initiative and put up the first plants which should serve as models. These drugs are needed by the poorest of the poor; they must be made available to the health authorities, Government hospitals and the public at the lowest possible cost. In the second group come drugs of vegetable origin. The production of the drugs from vegetable sources such as quinine, emetine, morphine, caffeine, ephedrine, santonin, essential oils, etc., should be developed to the fullest possible both for the needs of the country and also for export. These drugs are literally to be treated as wealth of the country to be developed as such. We should also include in this group the biologicals, vaccines and sera, liver extracts, glandular products etc. These are being produced in the country and their production should be improved and increased as demand for them increases. Insulin has yet to be produced in India on a commercial scale and its production should be taken up. The development of shark-liver oil industry requires a mention by itself. In shark-liver oil we have a much richer source of vitamin A than in cod-liver oil. Shark is abundant in Indian waters. This industry should be specially developed. In connection with this the panel is of opinion that a central board representing the relevant Departments of the Government of India, the department of fisheries of the different maritime provinces and non-official experts with a whole time executive should be formed to take the necessary steps to put the Shark-liver oil industry on a firm and permanent basis as explanied in paras. 89 and 90.

115. Along with the manufacture of drugs and fine chemicals, largely from imported material, we shall have to start a planned production of heavy chemicals, solvents and intermediates. We are not giving a programme of their manufacture since this can be drawn up only by integration of the reports of a number of panels, as we have explained above. We should, however invite attention to a number of basic chemicals which are of special importance to the drugs and fine chemicals industry.

116. Among the heavy chemicals, the manufacture of three items, chlorosulphonic acid, sodium and chlorides of phosphorus, is very important and should be taken up without delay. Of these, only chlorosulphonic acid is being produced in India but in small quantities and at prohibitive cost. This important chemical should be produced at a price that can compete favourably with the imported material. For the manufacture of sulpha drugs alone about 1500 tons of this material will be required per annum.

117. The production of intermediates from coal distillation products such as aniline, acetanilide, chlorobenzene, phenol, diethylaniline, para anisidine para nitrotoluone, phthalic acid and anhydride etc., requiresi mmediate attention. During the war, for defence requirements, plants were installed by the

Government of India for the manufacture of distillation products of coal. Consequently, India has now a production capacity of about two million gallons of benzene and half a million gallons of toluene. These are no longer required for defence purposes, and are now available for the industrial development of the country. The production of these should be kept up and they must be utilised for the manufacture of the intermediates mentioned above. Special efforts should be made to produce refined 2° pyridine which is essential for the manufacture of sulpha drugs.

118. Among the solvents, India produces ethyl alcohol in good quantities at competitive prices. Acetone is being produced at one of the Ordnance Factories from ethyl alcohol. Since the explosives are not now manufactured, there is no use for the acetone in the Ordnance Factory. If the production of acetone in this factory is kept up, the needs of the drug industry will be met to a great extent. Immediate arrangements should be made for the manufature of the other solvents, acetic acid, butyl and amyl alcohols in the country. Special efforts should be made to manufacture ethylene oxide, a very valuable intermediate, which is difficult to import because of its low boiling point.

119. Of the remaining items, the production of three chemicals, lactose, thiourea and guanidine nitrate, are important. Lactose is used for the manufacture of penicillin. Thiourea and guanidine nitrate are essential for the manufacture of the sulpha durgs.

120. We would like to take the opportunity of stressing again the proper plan for training scientists and technicians for developing industry in the country. As stated in para. 104, the panel is of the opinion that in each case the project must be first decided upon and men selected in India to fill these projects. Each man should be allotted a specific duty in that project, in consonance with his existing knowledge and training. They should then be sent abroad for training as teams with specific duties allotted to each. The full value of training can be derived only if well-trained men are sent abroad to specialise in specifically selected portions of a project. Thus a number of men would complement one another's knowledge and make a well-trained team to cover the whole project.

SUMMARY OF RECOMMENDATIONS OF THE PANEL.

(1) *Object to be achieved.—(Para 7.)*—The Panel considers that it should be the object to make India self-sufficient in regard to fine chemicals, drugs and pharmaceuticals within the next 15 years. The country must produce all essential drugs and make them available for the use of the masses at economic prices.

(2) *Raw materials for the manufacture of Fine Chemicals and Drugs.*— For the production of fine chemicals and drugs on a large scale, adequate quantities of the following groups of articles should be available :

(*i*) *Inorganic chemicals, (Para 10).*—Basic chemicals, such as the main acids and alkalies, common inorganic sulphates and phosphates and essential gases such as chlorine, ammonia, carbon-dioxide, hydrogen, etc. should be available in sufficient quantities and at economic prices. This question has already been dealt by the panel on heavy chemicals.

(*ii*) *Distillation products of coal, (Paras 11-18, 100).*—It would be necessary to develop coal distillation industry to the furthest possible extent and to place it on a sound and rational basis.

During the war the Government of India have set up two coke oven recovery units for the production of benzene and toluene at Jamshedpur and Hirapur. The plants should continue in operation. Until such time as the fine chemical industry is ready to absorb the products, they should be utilised as motor fuel.

It is absolutely necessary that the production of coal tar intermediates should be developed. At present these are not produced in India. The State should initiate the production of these items themselves and/or through private enterprise. The Fuel Research Board may be requested to consider the problem connected with the production of tar more suitable for by-product recovery from Indian coal. The coal tar intermediates for the preparation of drugs and dyes are common, and there should be close co-ordination in the plan for the development of the manufacture of dyes and drugs in this country.

(*iii*) *Wood distillation products. (Paras 19-21).*—Although the most important chemicals obtained from wood distillation, such as acetic acid, acetylene, methyl alcohol and formaldehyde are now produced synthetically in most countries, it is recommended that in parts of India, where there is demand for wood charcoal and suitable varieties of wood are available cheaply and in abundance, the possibility of economic production of these chemicals by distillation of wood may be further considered.

(*iv*) *Fermentation products. (paras 22-23).*—The fermentation industry is of the greatest importance to the country and its development should be taken in hand without delay.

(*v*) *Petroleum products—(Para. 24).*—It is considered that it should be possible to obtain from indigenous petroleum India's requirements for petroleum ether, liquid petroleum or white mineral oil and paraffin wax. Steps should be taken to produce required quantities of the above in the refineries in India.

(*vi*) *Animal products—(paras. 25-29)*.—The present arrangements for the collection of animal tissues and glands from the slaughter houses are very unsatisfactory. The materials should be made available to the manufacturers in a fresh condition to obviate any possibility of deterioration. Quick removal of the glands, etc. after slaughter and their immediate freezing on the spot will require to be provided. Cheap transport facilitis in cold storage will also have to be arranged.

About 8,000,000 c. cs. per month of bacterial vaccines are being produced at present in Government laboratories. Besides these existing laboratories, it is recommended that all Provincial Governments should organise their own bacteriological laboratories in the near future. It is necessary that the manufacture of Agar Agar from indigenous sources should be further developed. To meet the increasing demands for anti-toxins and sera, with the increase in medical relief organisations in the country, it is recommended that all Provincial Governments should organise their laboratories.

(*vii*) *Vegetable products* (*Paras 30-34*).—India is very favourably situated regarding the preparation of vegetable drugs. There are wide varieties of soil and climatic conditions in which medicinal plants of all kinds can be grown. With careful cultivation, the resources of the country in this direction could be greatly increased. Steps to be taken to increase the cultivation of medicinal plants should have in view not only the requirements of the country, but also the export trade. An inquiry should be instituted into the whole question of production of these drugs on a large scale so as to improve the quality and reduce the cost and enable Indian products to meet foreign competition.

There should be a Government organisation in each Province or group of Provinces for improvement in cultivation and collection of medicinal plants. The Government should also organize stores where vegetable drugs of all kinds properly stored and graded would be available in good condition to drug manufacturers.

Plants from which important fixed and essential oils are obtained are all grown in the country. If the raw materials are properly collected, adequate quantities of oils could be produced. It will not only be sufficient for the internal demand but will leave enough for export purposes.

(*viii*) *Synthetic chemicals* (*Paras. 35-39*).—Synthetic chemicals industry has hardly been developed in the country. The preparation of synthetic methyl alcohol from carbon monoxide and hydrogen and of synthetic chemicals from acetylene, ethylene, etc., will have to be developed on a large scale. Synthetic production of drugs and fine chemicals from intermediates derived from the distillation products of coal such as benzene, tolueno, naphthalene, anthracene also should be developed.

(3) *Difficulties hampering the development of the manufacture of Fine Chemicals and Drugs (paras. 41-46)*—The main difficulties are the following :—

(*i*) *Supply of raw materials (Para. 42).*—The basic chemicals such as the main acids and alkalies are available but the prices of these are in many cases too high. The basic chemicals should be available to the Indian manufacturers at economic prices. The manufacture of adequate quantities of solvents, crude vegetable drugs of proper quality, and intermediates from the distillation products of coal should be organised on a sufficiently large scale.

(*ii*) *Heavy cost of transport (Paras 43 and 109).*—The cost of transport of raw materials and finished goods from one part of the country to the other is too high at present. This is an important factor in raising up the cost of production of Indian goods and is responsible for the difficulties experienced by Indian manufacturers in facing competition from abroad. The railway freights on drugs and chemicals should be cut down to the minimum.

(*iii*) *Provincial excise rules (Paras. 44-45).*—The manufacturers and distributors are greatly handicapped at present owing to the existence of different excise rules in different provinces. Indian made spirituous preparations cannot be transported from one part of the country to the other without overcoming a great deal of vexatious interference. A uniform excise policy should be adopted throughout the country and local variations in excise rules should be abolished, as far as possible. The excise duty on spiritous, medicinal and other preparations in the provinces and States should be uniform. Indian made spirituous preparations should be allowed to move freely throughout the country, in the same way as imported spirituous preparations, when once the duty has been paid at the place of manufacture.

(*iv*) *Lack of control over standards (Paras. 46-47).*—Spurious drugs and alkaloids, and biological products below thier strengths are still being allowed to be sold with impunity. This acts prejudicially against the interests of the honest manufacturers and leads to lowering of confidence in Indian products. The Panel recommends that the Drugs Act should immediately be brought into force. The Provincial Governments should take steps to organise drug testing laboratories to implement the Act. The Pharmacy Act should also be brought into operation as early as possible.

(*v*) *Existing patent laws (Para. 48).*—Most of the important processes for the manufacture of drugs and fine chemicals urgently needed for the country are covered by foreign patents. Under the existing Patents Act it is practically impossible to obtain a compulsory licence from a foreign patentee. It is understood that so far there has not been a single case in India where a compulsory licence has been granted under the Patents Act. It is suggested that Sections 22 and 23 of the present Patents Act should be revised in consultation with the Controller of Patents.

(4) *Non-ethical Patent and proprietory medicines (para. 49).*—Immediate and drastic steps should be taken to eliminate as far as possible the trade in non-ethical patent and proprietory medicines and secret drugs, which is thriving on the ignorance and credulity of the people.

(5) *Importance of concentrationg on the manufacture of some essential drugs Paras. 50-93).*—There are certain essential drugs for which the need is very great and urgent. The Panel considers that attention should be specially concentrated on the production of the following articles of vital importance for the health and well-being of the nation in quantities as shown against each

Vegetable drugs.	Target of production in 10 years.
Quinine	2,000,000 lbs. per annum within 15 years.
Pyrethrum	50,000 tons of dried pyrethrum flowers per annum.
Emetin	2,000 lbs. per annum.
Strychnine	16,000 lbs. per annum.
Santonin	3,000 lbs. per annum.
Ephedrine	5,000 lbs. per annum.
Caffeine	30,000 lbs. per annum.
Morphine	3,000 lbs. per annum.
Synthetic drugs.—	
Sulpha drugs	500,000 lbs. per annum.
Mepacrine	160,000 lbs. per annum.
Paludrine	Target not fixed.
D. D. T.	30,000 tons per annum
P-carbaminophenyl Arsonic acid (carbarsone)	50,000 lbs. per annum.
Sulpharsphenamine and Neoarsphenamine	50,000 lbs. per annum.
Anti-biotics—	
Penicillin	1,000,000 million units per annum.
Streptomycin	As much as possible.
Vitamins—	
Vitamin A	1,000,000 gallons of shark liver oil of potency 6,000 units per gramme.
Vitamin B (group)	Targets not fixed. The Technical and Planning Panels of the Food Department are dealing with this question.
Vitamin C	
Vitamin D	

(6) *Targets for fine chemicals, solvents and photographic materials (Para. 40)* —In addition to the items mentioned above, targets of production by the end of the next 10 years have been fixed for various other fine chemicals, drugs, solvents and photographic chemicals, which may be seen in para. 40.

(7) *Equipment and machinery—(Paras. 97-98).*—Glass apparatus and equipments such as percolators, concentration pans, filter presses, contrifugals distillation columns, incubators, ovens and simple autoclaves are made in the country in small quantities. Special acid and alkali resistant vessels such as enamelled, Porcelain, glass and rubber lined stills, kettles, pots, etc. and vessels made of stainless steel, monel, inconel etc. are however not made in India. While attempts should be made to manufacture such equipments in the country it will be necessary to import these materials from abroad for some time in order not to hold up the expansion of the fine chemicals and drugs industry.

(8) *General questions of policy—(Para. 100-111).*

(*i*) *Management of industry—(Para. 100).*—The Panel considers that in the manufacture of new and vitally important drugs like penicillin, streptomycin mepacrine, sulpha drugs, etc. the State should take up the initiative and should take up production and it should at least put up the first plants to serve as models and to train up personnel. The State should also initiate the production of coal tar intermediates themselves and/or through private enterprise.

(*ii*) *State aids* (*Paras. 101 103*).—The State should take up initiative with a view to help the industry and set up pilot plants, where necessary. Production should be started wherever necessary with imported basic and intermediate materials.

The nascent industries will have to be protected. The exact method by which this can be achieved would depend on the industry concerned.

Research on fundamental problems connected with the manufacture of fine chemicals, drugs and pharmaceuticals should be liberally subsidised by the Government. Certain experts may have to be provided by the Government to advise industries on specific problems connected with the production.

(*iii*) *Training of techincal personnel* (*Para. 104*).—Steps should be taken for training scientists and technicians for developing industry in the coutnry In each case the project must be first decided upon and men selected in India to fill these projects. Each man should be allotted a specific duty in that project in consonance with his existing knowledge and training. They should then be sent abroad for training as teams with specific duties allotted to each. The Government should arrange that suitably qualified university graduates may receive practical training in the manufatcure of fine chemicals and pharmaceuticals in the manufacturing concerns in India.

(*iv*) *Foreign capital* (*Para 105*).—While the Panel considers that it will be preferable to be independent of foreign capital and management, it is felt that this question will have to be considered on the merits of each case.

(*v*) *Location of industries* (*Para 106*).—The different units should be located primarily on the consideration of availability of raw materials, labour consumption and distribution facilities in relation to other industries.

(*vi*) *Association of industries* (*Para. 107*).—The Panel considers that an association of industries would be of considerable help in the development of new industries. But cartels are considered definitely undesirable.

(*vii*) *Customs duty* (*Para 108*).—The Customs duty on raw-materials and semi-manufactured goods required for the industry should be remitted for the first 5 years and the duty on finished materials should be increased gradually as soon as manufacture begins to develop. Capital goods required for the industry, should be allowed to be imported free of duty for the first ten years.

(*viii*) *Railway freights* (*Para. 109*).—The present Railway freights on raw materials and finished goods are extremely high and act as deterrant to the development of the fine chemicals and drugs industry. The railway rates should be revised and brought down.

(*ix*) *Excise policy* (*Para. 110*).—A uniform excise policy should be adopted throughout the country and local variations in excise rules should be abolished. The excise duty on spirituous, medicinal and other preparations in all provinces and states should be uniform. Indian made spiritous preparations should have the same facility of movement from one part of the country to another as imported spirituous preparations, when once the duty has been paid at the place of manufacture.

For the manufacture of fine chemicals and drugs where sugar is used as a basic raw material, the present excise duty on sugar should not be levied.

(*x*) *Export* (*Para. 111*).—Scope for export exists and full use should be made to develop the export markets.

(9) *Stages by which the Fine Chemicals and Druqs Industry is to be developed* (*Paras. 112-120*)—(*i*) The Panel considers that the production of two types of drugs should be taken in hand immediately, viz., (1) those which are essential for guarding the health of the public and warding off infectious diseases, (2) those for which India already has or can easily develop raw materials in abundance. Under the first category come the sulpha drugs, anti-malarials (quinine, mepacrine, pamaquine, paludrine) penicillin and streptomycin. The arsenicals and DDT can also be included in this list. In the second group come the drugs of vegetable origin. Products such as quinine, emetin, morphine, caffeine, ephedrine, santonin and essential oils, etc. should be developed to the fullest possible extent, both for the needs of the country and also for export. These drugs are literally to be treated as the wealth of the country to be developed as such. We should also include in this group the biologicals, vaccines and sera, liver extracts, glandular products, etc. Production of insulin on a commercial scale should also be taken up.

There is scope for large expansion of the shark liver oil industry in the country. This work should be taken in hand immediately. In shark liver oil we have a much richer source of vitamin A than cod liver oil. Sharks are in abundance in Indian waters. A central board, representing the relevant departments of the Government of India, the Departments of Fisheries of the different maritime provinces and non-official experts, with a whole time executive should be formed to work out the necessary steps to put the shark liver oil industry on a firm and permanent basis.

(*ii*) The practical way to establish the fine chemicals and drugs industry will be to decide upon the minimum number of drugs and fine chemicals essential for the country. The production of essential drugs should not wait on the production of basic chemicals in the country. We should on the other hand immediately start with the manufacture, utilising the raw materials already available in the country and importing those not available here till we develop our resources.

(*iii*) Among the heavy chemicals, the manufacture of three items, *i.e.*, chloro-sulphonic acid, sodium and chlorides of phosphorus, is very important and should be taken up without delay. The production of intermediates from coal distillation products, such as aniline, acetanilide, chloro-benzene, phenol diethyl aniline, para-anisidine para-nitrotoluene, phthalic acid and anhydride etc., requires immediate attention. Special efforts should be made to produce refined 2° pyridine, which is essential for the manufacture of sulpha drugs.

(*iv*) Among solvents India produces ethyl alcohol in good quantities at competitive prices. Acetone is being produced at one of the Ordnance Factories. This acetone is not required now by the Ordnance Factory for the manufacture of explosives. If the production of acetone in the factory could be kept up the needs of the drug industry will be met to a great extent. Immediate arrangements should be made for the manufacture of other solvents such as acetic acid, butyl and amyl alcohols and also of ethylene oxide which is a valuable intermediate.

(*v*) Steps should also be taken for the manufacture of requisite quantities of lactose, thiourea and guanidine nitrate, the first of which is required for the manufacture of penicillin and the second and third for the manufacture of sulpha drugs.

(*vi*) The Panel feels that the proper development of the fine chemicals and drugs industry leading to self-sufficiency requires a well balanced and integrated plan for the production of heavy chemicals, coal distillation products, organic solvents etc. The production of these starting materials has to be linked up not only with the needs of the drugs and fine chemicals industry but also with those of the dye-stuffs, artificial fibre, plastic, synthetic rubber industries, etc. A programme of production, thus, can be drawn up only by integrating the reports of different panels dealing with the planning and production of the above mentioned raw materials and finished products. The present panel is not in a position to draw up the needed programme in a very concrete way. It recommends that the Government should now set up a technical planning commission to prepare concrete and detailed plans for the development of each of these industries and finding ways and means of implementing these plans.

R. N. CHOPRA, *Chairman.*
S. S. SOKHEY.
J. N. RAY.
K. A. HAMIED.*
B. B. DIKSHIT.
C. J. FIELDER.
HABIB HASAN.
B. C. GUHA.
V. SUBRAHMANYAN.
K. GANAPATHI.
M. B. AMIN.
N. ADHIKARI
} *Members.*
M. K. MAITRA. *Secretary.*

*Signed subject to the note of dissent pp. 42--50.

MINUTE OF DISSENT

BY

DR. K. A. HAMIED.

While the Fine Chemicals, Drugs and Pharmaceuticals Panel has fully emphasised in the Report the necessity and urgency of development of Fine Chemical and Pharmaceuticals Industries in India, it has expressed in several places views with which I cannot agree. In certain places, definitions in the Report are technically wrong.

Several questions arising out of the Terms of Reference, such as (1-A) (2), (3), (4), (5), (8), (12), have not been properly dealt with. In many places the Report does not lay sufficient emphasis uopn its recommendations. The whole Report is more biassed towards the manufacture of drugs rather than chemicals. The manufacture of drugs is subsidiary to the manufacture of heavy and fine chemicals, and hence more emphasis and attetion should be applied to the manufacture of fine chemicals which will lead to the manufacture of all drugs.

As I had gone out of India with the Indian Chemical Manufacturers Delegation to U. K. and U.S.A., I was unable to attend the meetings of the Panel except the last one held on 3rd May 1946, when the final Draft Report was placed before the meeting after discussion. Since the majority of the Members of the Panel did not find it possible to agree with my views, I had to submit this Minute of Dissent.

I. *Erroneous Definitions.*—The distinction between Fine Chemicals, Drugs and Pharmaceuticals as stressed in paragraphs 4 and 5 of the Report is not technically correct. It is stated that chemicals which are produced and consumed in very large quantities are usually described as heavy Chemicals, whereas those which are manufactured in comparatively small quantities are described as Fine Chemicals. This distinction between Fine and Heavy Chemicals is erroneous. The fact is that scientifically there is no distinction between the two. Certain chemicals, such as Sulphuric Acid, Hydrochloric Acid, Nitric Acid, Caustic Soda, Soda Ash, Chlorine, etc., have been by usage in popular language, termed Heavy Chemicals. Perhaps this was due to the fact that in former times these were the only chemicals requiring heavy plant and machinery. The rest of the chemicals not included or allied to these were known as Fine Chemicals. At present this distinction also does not exist, but the terms " Heavy " and " Fine Chemicals ", continue to be vaguely used.

In para. 5 it is stated, " A large proportion of Fine Chemicals is used as Drugs ". The word " Drug " is not defined at all. Pharmaceuticals are described as " Preparations of Drugs made up for use". The entire paragraph is misleading. In the language of Chemistry the word " Drug " does not appear at all. It is a layman's word used to describe ready -made medical products. Correctly speaking the word " Pharmaceutical " which is now used in scientific language, is identical to the word " Drug ". In Germany and other Continental countries, the word " Drug " (Drogen), is only used for medicines derived from herbs and plants. In my opinion, the word " Drug " should be completely removed from the Report and the Government be requested to rename the panel as " The Panel on Fine Chemicals and Pharmaceuticals. "

II. *Distillation Products of Coal.*—In paragraph 15, page 8 the last two sentences read :—" Benzene and Toluene are produced in Coke Oven Gas Recovery Units at the Steel Works. These plants are Government owned and it is desirable that the Government of India should continue them in operation, utilising the products as motor fuel until such time as the Fine Chemical Industry is ready to absorb them ". I do not know whether the Coke Oven Gas Recovery Units belonging to the Steel Works producing Benzene and Toluene are Government owned. The Government have their own Coke Oven Gas Recovery Units apart from these owned by the steel works. I do not agree that the Government should continue to own and operate these plants and utilise the products as motor fuel. The Government should hand over these plants immediately to proper chemical industrial concerns for utilising Benzene, Toluene and other products for the manufacture of various essential organic chemicals.

III. *Objects to be Achieved & Targets for production.*—The objects to be achieved, as mentioned inpara. 7, are based more on sentiment than on facts. No country is, or can be, self-sufficient in regard to Fine Chemicals and Pharmaceuticals. One is dependent on another. In many cases it will be impossible to make Fine Chemicals for which facilities and raw materials are not available in this country. In other cases, it may happen that certain chemicals can be produced but not cheaply enough. The aims and objects, therefore, should be to see that all Fine Chemicals and Pharmaceuticals which *can* be produced from raw materials available in this country are manufactured in sufficient quantities for the requirements of the country within the next 15 years. It should not be the aim to try to manufacture what other countries are manufacturing but to manufacture what India can manufacture from raw materials available in India.

The targets for production, as given on pages 17, 18 and 19, for pharmaceuticals and fine chemicals are, in my opinion, arbitrarily fixed. The list is not fully representative of the vast range of fine chemicals. Undue preponderance and emphasis has been given to pharmaceuticals. Fine Chemical Industry both organic and inorganic, should be the main subject of recommendation as manufacture of pharmaceuticals, specially of the synthetic ones is subsidiary to the manufacute of fine chemicals. Further, the Report recommends the production of each individual chemical and pharmaceutical mentioned in the Report. It is not possible to deal with the manufacture of chemicals and pharmaceuticals individually. It is well known that in chemical and pharmaceutical manufacture, one product leads to the manufacture of another. It is in fact by this process that the Chemical and Pharmaceutical Industry has gradually developed throughout the world. The same process of development will have to be followed in India.

IV. *Difficulties Hampering the Development of Fine Chemical & Pharmaceutical Industry.*—Before going into the question of planning the development of Fine Chemical and Pharmaceutical Industry, it is necessary to analyse the causes which have been responsible for the non-development of such industries in India. Without this analysis no plans for the future can be properly made. If the causes and factors hampering this development in the past are once known and eliminated, the industry will automatically expand and develop. The Report has very briefly touched this problem (paras. 41 to 48), and its recommendations also are not very emphatic.

In my opinion, the undermentioned difficulties are completely blockading the establishment of new and the development of existing Fine Chemical and Pharmaceutical Industry in this country.

(1) *Cost of Transport.*—For any industry to be established and run economically, the cost of transport of basic materials and finished products must be as low as possible. In India, although the railways are State-owned, the cost of transport is excessive. As an example, I would add that the freight on chemicals in U.K. is about Sh. 50/- to Sh. 90/- per ton for a distance of 500 miles, whereas in India the freight is Rs. 4/6/- per maund, which works out @ Sh. 180/- per ton. This is more than double the freight in U.K. The result of such heavy cost of transport is, that basic chemicals already available in India, such as Benzene, Toluene, Naphthalene and subsidiary chemicals such as Acids, Alkalis, Chlorine, etc., are not being utilized for the manufacture of fine chemicals, both organic and inorganic. A number of dyes can also be made immediately in India from these same raw materials, but the cost of transport alone makes it prohibitive for any chemical industrialist to undertake to establish such industries. The existing chemical and pharmaceutical concerns cannot expand their activities also due to the same cause.

With the question of transport is connected the question of containers necessary for the movement of basic chemicals. There are no facilities provided by the railways in India of Tank Wagons for the transport of corrosive, non-corrosive and inflammable chemicals. The existing practice of packing in jars, drums, etc., is too costly and therefore uneconomic. In U.K. and U.S.A. the railways provide Tank Wagons for the transport of all types of basic organic chemicals, such as Benzene, Toluene, Phenol and also for Liquid Chlorine and Acids, the latter being made of non-corrosive material. How this is hampering the development of industry can be visualised from the fact that Sulphuric Acid, one of the very important basic subsidiary chemicals, cannot be transported from one place to another due to high cost of transport and non-availability of Tank Wagons. With the result that in certain places in India Sulphuric Acid is in abundance while in others there is a shortage. In America and U. K. transport facilities for all types of chemicals, both organic and inorganic, are so great that chemical industries have been started at hundreds of places. In India, important basic organic chemicals, such as Benzene, Toluene and Naphthalene are produced in moderate quantities for production of a large number of intermediates, fine chemicals and pharmaceuticals. It is unfortunate that these important basic materials, although available, are not utilised for this purpose. Benzene is being used as motor fuel and Toluene and other basic materials are lying unused.

India produces a number of medicinal plants rich in Alkaloids and Glucosides and Essential Oils. These plants generally grow in hilly regions, such as Kashmir, Himalayas, Baluchistan and in the South. The active principles contained in these medicinal plants are generally in the neighbourhood of 1%

to 2%. The cost of transport, therefore, plays a very important role if these raw materials are brought from the places of their growth to the places where extraction and manufacture of the active substances takes place. If India is to develop her alkaloid Industry, the cost of transport must be reduced to the very minimum. In short, from what I have said above, it will be clear that this one factor alone, namely the high cost of transport and the non-availability of tank wagons, has been responsible for the non development of fine chemical industries in India. If it is desired that this industry should expand and grow without any further delay, the best plan would be to bring the freights for raw materials and finished products to the lowest possible level.

(2) *Import Duties.*—This is another factor which unnecessarily raises the initial capital for starting of industries. No tariff duties should be imposed on the import of machinery when such machinery is not manufactured in the country and is urgently required for the development of vital industries. Chemical Industries depend to a great extent on experimentation and research. They have to maintain Industrial Research Laboratories and are faced with the difficulty of paying enormous sums in the form of Customs Duty to the Government on scientific research apparatus so vital for the development of Chemical Industries of the country.

Technical personnel, good or bad is today being recruited by the Industry from the existing Universities and Technical Schools in India. The training of these technical men remains of a low standard as the universities and technical schools from their meagre finances, cannot afford to purchase sufficient laboratory apparatus needed for research and teaching on account of the fact that the cost of equipment increases by 30% due to Customs Duties. It is therefore, imperative that Customs Duties must immediately be abolished on all types of chemical laboratory apparatus for teaching and industrial research.

The manufacture of a number of essential pharmaceuticals, specially synthetic chemo-therapeutic substances, depends on the availability of fine chemicals. So long as these chemicals are not manufactured in India, it is desirable that Import Duties on basic fine chemicals required for the production of essential pharmaceuticals should be waived.

(3) *Import Trade Control.*—Another difficulty which is facing the manufacturers today and stands in the way of rapid development of Chemical industries, is the Import Trade Control. It was believed that these import controls will be terminated soon after the war, at least for the sterling areas. But it appears that there is no sign of decontrolling the import of machinery from non-Sterling or Sterling areas. Even small machines required for the Pharmaceutical Industry which are available in England and the manufacturers there ready to supply, cannot be purchased before several months are wasted in obtaining a permit for import of such machinery from England. In a country like India, where manufacture of plant and machinery for the Chemical Industry is practically non-existent, all types of restrictions on the import of machinery should be immediately removed.

(4) *Excise Rules.*—Alcohol is an essential constituent of a number of harmaceuticals. In many others it is used during the manipulations of

manufacture. Several fine chemicals also require alcohol for crystallisation and purification. The present Excise Laws were framed as late as 1878. At that time no Fine Chemical and Pharmaceutical Industry existed in the country. A change in these laws is essential. These laws do not contain any provisions for the use of alcohol in pharmaceutical and fine chemical industry. In U. K. Industrial Alcohol is provided by the Excise. This alcohol is good enough for all chemical processes but not for potable use. Hence the use of this Industrial Alcohol by chemical and pharmaceutical manufacturers does away with the various restrictions of Excise Laws. No such industrial alcohol is available in India. The system of filling up a number of forms and maintaining a number of voluminous registers causes great inconvenience and delay. The Industry, therefore, besides other difficulties is suffering from the existing Excise Laws.

Further, the Excise Laws vary from Province to Province restricting the free movement of Spirituous Pharmaceutical Products which increases the difficulties of the trade and hamper the development of the Pharmaceutical Industry. Representations made to the Government by Chemical and Pharmaceutical Associations and individual firms have been in vain. Foreign made pharmaceutical products as well as toilet preparations containing alcohol have no such difficulties to encounter as once the duty is paid at the port of entry, there is no provincial excise barrier to restrict their free movement. The Excise Rules must, therefore be immediately revised and brought in conformity with similar rules in U. K. and other countries.

In my opinion, therefore, the first and foremost essential step towards planning for the development of chemical and pharmaceutical industry should be the removal of the main existing difficulties stated above. Further facilities and help as may be required by the industry should be given promptly. This alone more than anything else, would result in an immediate expansion of the existing industries and lead to the opening of new chemical concerns who will be in a postion to undertake of their own accord the manufacture of hundreds of items belonging to this industry.

V. *Lack of Control over Standards.*—The Panel was required to go into the question of Controls if any which should be exercised by Government if the industry is to be under private ownership and managment. (Terms of Reference No. 8). The Report has not dealt with this question at all. Under the caption " Difficulties Hampering the development of Fine Chemical and Pharmaceutical Industry " (paragraph 41) the Report has dealt with the lack of Control over Standards as one of the causes hampering the development of Chemical and Pharmaceutical Industry. Paragraph 46 of the Report deals with the lack of Control over Standards. Again it is evident that the authors of the Report have in mind only the control over drugs and pharmaceuticals. I do not agree with the remarks in paragraph 46 of the Report : " Spurious drugs and alkaloids and biological products below their strengths are now being sold with impunity. " This is a very sweeping statement and should not have formed part of the Report. Many important Alkaloids, such as of the Opium Group, are made and sold only by the Government at their Ghazipur Factory and hence should not be spurious. Biologicals are made by a few important private concerns in Calcutta, the Haffkine Institute at Bombay and few other Government Institutions and it is claimed by them that their products are not below the Standards.

While fully agreeing with the necessity of the Drug Act to come into opeiation as soon as possible, I. however, feel that it is not only desirable but very necessary for the Government of India and Provincial Governments to take immediate steps to establish Chemical and Drug Testing Laboratories. Analytical Control and testing of chemicals and pharmaceuticals is not an easy work. Besides first class special equipment, the work requires highly trained and qualified personnel. It is beyond the capacity of an ordinary B.Sc., M.Sc., or even a D. Sc., to analyse drugs and chemicals, unless he has a full training in such work. The establishment of Laboratories, therefore, must go hand in hand with the training of expert personnel. Steps, therefore, should first be taken to determine the number of personnel, their qualification and training required for working in all the Testing Laboratories in India. Arrangements should be made to have the personnel trained and at the same time the Laboratories established before bringing the Drug Act in operation. To introduce the Drug Act and bring it in operation without the establishment of such Laboratories will, in my opinion, be injurious to the trade and liable to lead to mal-practices.

The same remarks, more or less, apply to the introduction of Pharmacy Act. The Phaimacy Act is very essential but before it is introduced, full arrangements must be made for the training of compounders in suitable schools which must be immediately established for this purpose.

VI. *Patent and Proprietory Medicines.*—The Report has devoted a full and lengthy paragraph (49), to this subject. It is irrelevant to the Report and the Terms of Reference for which the Panel was constituted.

The manufacture of and trading in patent and proprietory medicines had become a world industry and ranks probably among the third of the major industries of the world. In countries like U. S. A., U. K., and other continental countries, the practice of prescribing patent and proprietory medicines has completely overshadowed the old practice of writing long prescriptions which is still prevalent in this country. It is the result of our present-day civilisation which has brought speed and activity in every sphere of life. A prescription as written by a doctor takes hours and hours to dispense—sometimes one has to wait for a whole day. This in fact is the cause for the continuous increase in the demand of patent and proprietory medicines which are sold ready-made at the counter requiring no waste of time.

In a country like India, two crores worth of patent and proprietory medicines, as gauged in the present Report, is not a big figure at all. In U. S. A. with a quarter of the population of India, the sale of patent and proprietory medicines is several times greater. Same is the case in U. K. and other countries of Europe. Expressions such as " Barring a few exceptions these preparations are entirely worthless. Some of them actually contain ingredients that are positively injurious................they cause incalculable injury by leading sick person to delay in securing proper medical treatment " are positively wrong, misleading and calculated to cast a slur not only on the Indian patent and proprietory medicines but on those of the entire world. Further statements made in that paragraph mention, " The trade in *secret drugs* is thriving on the ignorance and credulity of the people. " I cannot understand what the authors of the Report had in mind by the words Secret Drugs ". If they mean Ayurvedic and Unani medicines, then they have no right to class them as such because they are ignorant of the Unani and Ayurvedic medicines and cannot pronounce opinion on a completely different system of therapy with which they are not familiar and which has been in practice in India since time immemorial. If by " Secret Drugs " they mean Patent and Proprietory Medicines of the Western System, then again the authors of the Report are wrong to term them as " Secret ", because no manufacturer in India or abroad, worth the name is producing " Secret Drugs " for which the authors have estimated the value of 2 Crores in India and much bigger in America and U. K. Formulae and composition of almost every patent and proprietory medicine is mentioned on each and every package. What is more surprising is the fact that under the Targets of Production, the authors of the Report have themselves mentioned the names of a number of patent and proprietory medicines which they wish to be made in India.

Personal sentiments and prejudices should not have been brought into the Report.

VII. *Private or State Ownership of Industry.*—The Terms of Reference No. 2 reads : " Whether the industry should be under Government ownership either on grounds of National interest or because private capital is unlikely to take it up and if so, whether it should be wholly or partly managed by Government. " This question of State Ownership as against Private has not been properly dealt with in the Report. In fact it was not possible for a Panel like ours to give a decisive opinion on this question which is facing the world today. I, therefore, feel it necessary to express my views on this very important question.

Apart from Soviet Russia where under a rule of dictatorship, industries are State-owned and State-controlled, in no other country of the world industries are under State Ownership. Private Ownership has the great advantage of free competition between industry and industry whereby each manufacturer is forced to develop new methods of manufacture. This leads to continuous scientific industrial research and advancement. The development of science and industry as it is today in the world, has been achieved through private enterprise during the last fifty years.

Under a democratic system of Government where people are free to live and act as they like, it is not possible to introduce the system of State-ownership of industries. The technical man under a democratic system, whether in the upper or lower grade, is free to work or not. He can therefore, refuse to work in State-controlled industries and the State will have no means of compelling a technical expert or a labourer to work. It is only under a dictatorship rule that labour, both manual and technical, can be compelled to work, as is the case in Soviet Russia, or was in Nazi Germany and Fascist Italy. In a free civilized country, run under a democratic system of Government, such ownership and control is, therefore, not possible.

It has been observed that whenever an industry is taken over by the State, it becomes stagnant for want of competition. This is no where more true than in India. State Officials in-charge of industries are irremovable from their posts and do not act with the same spirit as managers and supervisors work in private-owned industries. To give a few examples : Compared to the private owned systems in U. K. and U. S. A., the Railway System in India, which is State-owned, is functioning much worse not only in respect to railway fares, freights, but in respect of comfort and travelling, conditions of carriages and bad management, both as regards accomodation and timings of trains. The Telephone Company in Bombay, since it has been taken over by the Government, has been functioning worse than ever. Certain factories, such as for the production of Opium Alkaloids at Ghazipur, the Quinine Factories in Madras and Bengal, are not working as business concerns producing such products should work. In view of these conditions prevailing in the existing State-owned industries, one is doubtful whether more industries, specially those requiring expert technical knowledge and management like the Chemical and Pharmaceutical Industry, should be State-owned and Managed.

Further it is admitted by the Provincial Governments as well as by the Central Government that there is corruption in number of Government Departments. It has been found necessary by the Provincial Governments to appoint special Anti-Corruption Boards to remove all types of mal-practices. Under such circumstances, there does not seem to be any necessity for the Government to take the burden of opening new departments by undertaking the ownership, management and control of complicated industries.

The Report has not properly dealt with Item (3) of the Terms of Reference. Private Capital has always been forthcoming whenever an industry could be established on reasonable economic basis. The causes which have been responsible for non-expansion of chemical and pharmaceutical industry on a much larger scale than at present have been analysed by me in paragraph IV of this Minute. The scarcity of Capital has never been the cause. At present Capital is much more available for establishing new chemical industries provided, however, the hindrances which stand in the way of development and economic running are removed.

If, however, in spite of the removal of all these causes, the Capital is not yet forthcoming, the Government, taking into consideration the importance of any particular requirement of the industry, may invest part of the capital in order to attract larger public capital. In such cases Government naturally will have the right of participation in the management of the concern in proportion to the capital invested by the Government. This system is being practised today by the Indian States where we find that the industries are more rapidly growing than in British India. The Indian States are further helping the establishment of Industries by affording various facilities, such as free land, remission of income-tax for a period of 5 to 10 years and patronising the products manufactured in the States.

In the case of such industries as may be vital in the interest of the Nation and yet no private capital be forthcoming for any reasons, the State has certainly the right of starting such industries.

VIII. *Location of Industries* (*Terms of Reference No. 6*).—I do not agree with the Report (paragraph 106), that " Industries should be located primarily on the consideration of availability of raw materials labour, consumption and distribution facilities. " The location of industries* is mainly a matter of convenience to the promoter of the industry. Consideration of availability of raw materials at the spot is not a very big factor. Some of the best products are manufactured at places in various centres of the world from raw materials brought from far off places to the place of manufacture. Trained labour is a factor to be taken into consideration but this also is not the decisive factor. Consumption of the articles manufactured and facilities for their distribution take a secondary position in relation to other facilities which the promoter may find convenient for himself.

The location of industry, therefore, should mainly be the consideration of the promoter of the industry who, when investing large capital, is surely capable and careful enough to ascertain the best locality where he should establish that industry.

The Terms of Reference No. 8 has been wrongly construed in the Report. Under control, the Report seems to have taken the view Drug Control and as such emphasised the necessity of bringing into operation the Drug and Pharmacy Acts (paragraphs 46 and 47). Regarding the Drug Act and the Pharmacy Act, I have expressed my views in paragraph V above.

Regarding the controls which Government desires to know should be exercised if industry is to be under private ownership, are quite different from the controls under the Drug Act and Pharmacy Act. If industry is to be private-owned, as I have emphasised it should be, for reasons given in pharagraph VII of this Note, the controls fall under three categories :

(1) The control of Standards and Quality.

(2) The Control of Capital Issue, Location.

(3) Labour Welfare.

The first is covered by the Drug and Pharmacy Acts. The third is covered by the Labour Dispute and Industrial Act and the second requires no control, if industry is to flourish and expand on a wide scale.

IX. *Cottage Industry.*—Item No. 12 of the Terms of Reference, namely " Should the Industry be developed as in Japan on the Cottage Industry basis, and if so, to what extent ", has not been dealt with in the Report at all. Fine Chemical and Pharmaceutical Industry cannot ever be made a cottage industry like other industries, such as glass, match-making, textile, etc. Chemical Industry is a highly technical one and has no chance of developing on the basis of cottage industry. So far as I know this industry was never a cottage industry in Japan as the Terms of Reference suggests.

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* The industries referred to here are only fine chemicals and pharmaceuticals.

APPENDIX I(*a*)

NOTES ON THE GALENICALS AND TARGET PRODUCTION OF ALKALOIDS

BY MR. M. B. AMIN.

As agreed in the first meeting of the Panel on Fine Chemicals, Drugs, and Pharmaceuticals, I take pleasure in submitting here below my notes for the production of Galenicals and the proposed Target of production of the Alkaloids-Caffeine, Ephedrine, Emetine Morphine, Quinine and Strychnine.

Note on Galenicals.

By Galenicals it is generally meant the drugs of the vegetable kingdom usually extracted and preserved by the Alcoholic media. Thus the Extracts and Tinctures make a section of medicines commonly called Galenicals. Requisites of the Galenical Industry. The Chief requisites are (1) Vegetable Crude Drugs, (2) Alcohol, (3) Equipment and (4) Personnel.

(1) *Crude Drugs.*—In India with variable soil and climatic conditions most of the vegetable drugs as are commonly used in medicine grow freely. For several drugs that are not indigenous to this country, it is possible to find in some instances suitable indigenous substitutes, and in many cases it has been found possible to grow and acclimatise those drugs in this country. Thus so far as the basic need of the raw drugs is concerned, India can well afford to be self-sufficient in most of these important vegetable drugs.

(2) *Alcohol.*—It is needless for me to say that plenty of alcohol of indigenous manufacture is available in this country and this requirement can be met to the fullest without the least difficulty.

(3) *Equipment.*—As regards the equipment it is so simple that all what is needed for the industry can be fabricated locally by the engineering firms and copper and black smiths. The commonly needed equipment consists of percolators, jars, drug-mills and crushers, filter presses, filter stands, steam pans, vacuum stills, Drug stills, etc. In most cases tin-coated copper equipment serves the purpose but in some cases it may be necessary to have porcelain or enamel ware which it may be necessary to import.

(4) *Personnel.*—There are a number of Pharmaceutical Houses in this country with well established Galenical industry. There is enough trained and experienced personnel and there is no difficulty in this direction.

General remarks to achieve Target production.—The Panel has not yet fixed any Target figures for galenicals. It may, however, be said that the galenical industry is one of the long pre-war established industry in this country and in order to achieve any larger production for achieving the Target to meet any larger needs it is only a question of expansion of the existing industry and for such needed expansion the industry will be able to take care without any technical difficulty to meet the growing demands and achieve the target productions.

General Remarks.—Although the galenical industry is thus well established for long there are several handicaps for the smooth and economic existence and expansion of this industry and I would like to draw the particular attention to some of them.

(1) Galenical products consist mostly of extracts, Tinctures and as I have stated above they are alcoholic or spirituous products. Thus as these medicines contain alcohol these galenical drugs manufactured in this country have become victims of indiscriminate territorial excise restrictions, both as regards excise duties and their interterritorial movement from one province or State to another ; these restrictions are placed only on the products manufactured in India and not on those imported from overseas. The explanation as given by the Indian Govt. it is understood, is that the imported drugs form the subject of the Central Government and so the imported goods on which once the excise duty is paid at the port of entry can move freely in any part of India without any let or hindrance by the provincial or State Governments, but in case of the same drugs manufactured in India it becomes the provincial subject and so each province formulates and

exercises its own individual excise restrictions and regulations according to its fancy as regards duties and movement of those drugs from one province or State to another. Whatever may be the reasons, this discrimination between the imported and locally manufactured spirituous goods is neither logical nor sound and has stimulated imports at the cost of the Indian industry. So if Indian galenical industry is to thrive and expand the excise restrictions and regulations on the spirituous products manufactured in this country must also form the Central subject for unification of excise duties and free movement of the goods in any part of this country.

(2) Although most of the vegetable drugs as raw materials needed for the industry may likely be available within the country, there are some vegetable drugs which yet need to be imported as raw materials for the galenical industry I suggest that import of such crude drugs that do not grow at present in this country or are not available in sufficient quantities should be allowed to the Pharmaceutical industry for manufacturing purposes without tariff duties until they become satisfactorily available within the country. I further suggest that a list of such crude drugs that are needed to be imported for such manufacturing purposes be prepared for recommendation of exemption from import duties.

(3) In order to ensure reliable supply of indigenous crude drugs to the manufacturers it is desirable that (*a*) the Government should make and publish a comprehensive survey of the medicinally useful indigenous drugs giving names of the places where they grow ; the total quantities of each drug available at present ; the optimum conditions for their cultivation and growth ; the proper seasons of collection of the drugs and methods of their drying and storage for obtaining and preserving the maximum therapeutic value. The Government should also incorporate in this book the details of identification of those drugs and also set the purity standards and tests. Of course much of the information suggested above is available in scattered literature on drugs sporadically published by the Government as well as various eminent scientific workers as Sir R. N. Chopra ; however it is desirable to have an up-to-date revised authentic book giving all this information in an authoritative publication under the auspices of the Government and have it periodically revised to keep it up-to-date. (*b*) The Government should institute a bureau and a laboratory whose function should be to advise and help as to the cultivation, collection and distribution of drugs and also help whenever so desired in the identification and testing such crude drugs to their genuineness and medicinal stability. Also this bureau should maintain a museum of all authentic useful drugs for the above purpose.

(3) Ample transport facilities at specially low rates should be provided for transport of crude drugs.

(4) In the British Pharmacopoiea there are about 54 official galenical preparations from about 35 drugs all of which are being manufactured in India. Majority of the crude drugs need are available in India but there are a few important drugs that do not grow here and so in order to make this country self-sufficient in her needs of the important crude drugs the Government should carry on experiments to grow those important drugs that are imported and when successful immediate efforts should be made to cultivate those drugs on large scales to meet the entire needs of this country. Incidentally I may refer that two of the important drugs namely Ergot and Ipecacuanha, I understand have met experimental success for cultivation in this country and it is desirable that these successful experiments should be quickly commercially expanded to meet the whole need of the country. Similarly the Cinchona plantation should be rapidly expanded to meet the country's need for galenical preparations as well as for the manufacture of quinine to cover the entire need of the country to the fullest.

NOTES ON THE TARGET PRODUCTION OF THE ALKALOIDS.

The general methods of manufacturing alkaloids from the crude drugs are too well-known to be detailed here. The following are in brief the fundamental needs for the manufacture of Alkaloids from vegetable drugs.

Requisites for the manufacture of alkaloids.—(1) Crude drugs containing the alkaloids, (2) Organic solvents such as alcohol, Chloroform, Ether, Acetone, Benzene, Petroleum Ether etc., (3) Alkalis such as Caustic Soda, Lime, Sodium Carbonate, and Ammonia Acids chiefly Sulphuric and Hydro-chloric, (4) Equipment, (5) Personnel.

(1) *Crude Drugs.*—Resources for the manufacture of the alkaloids namely Caffeine Ephedrine, Emetine, Morphine, Quinine and Strychnine are Tea Waste Ephedra herb ipecacuanha roots, opium, cinchona bark and nuxvomica seeds respectively. All these six drugs grow in this country and in order to achieve the target production of the alkaloids what is necessary is to plan sufficient crops of these drugs so as to meet the needs for these drugs as specified later on under individual consideration of each alkaloid.

(2) and (3) *Solvents, Alkalis and Acids.*—All of them are produced in enough quantities in India and their production can be increased if need be and so there should be no difficulty for provisions of these requisites,

(4) *Equipment.*—Much of the equipment required is not complicated and it may be constructed locally. It may, however, be necessary to import some of the equipment such as enamelled or glass-lined ware, centrifugal machines, vacuum and solvent recovery stills etc.

(5) *Personnel.*—I feel there would be no difficulty to procure enough suitable workers from the country.

Quantities of Crude Drugs necessary for the Target Production of the Alkaloids.

Planning for the adequate local availability and efficient supply at competitive prices the necessary quantities of the crude drugs is most important. Here below, therefore, are detailed four estimated quantities of Crude Drugs necessary for the proposed Target Production of each Alkaloid.

Caffeine.—(Target production 30,000 lbs. per annum) Caffeine may be prepared from Tea Waste available in very large quantities in this country and in which it exists from 1 to 4 percent. Taking an average yield of about 2 percent, the quantity of Tea Waste annually required for the production of 30,000 lbs. Caffeine is 15,00,000 lbs.

Ephedrine.—(Target production 5,000 lbs. per annum)—Ephedrine may be prepared from the species of Ephedra herb indigenous to this country. The content of ephedrine in the crude drug varies from 0·5 to 1% of ephedrine. Taking an approximate average yield to be 0·75% of ephedrine, the annual requirement of the ephedra drug for the production of 5,000 lbs. ephedrine is about 6,66,800 lbs.

Emetine.—(Target production 200 lbs. per annum)—Emetine may be obtained from the Ipecacuanha roots in which it occurs from 1·25 to 2 percent. Taking an approximate yield at 1·25 percent the total quantity of the Ipecacuanha roots annually required for the production of 200 lbs. emetine is 16,000 lbs.

Morphine.—(Target production 3,000 lbs. per annum)—Morphine can be manufactured from Opium. Indian medical opium contains about 7 to 12% morphine. Taking an approximate yield of 10 percent Morphine from opium the quantity of opium annually required for the production is 30,000 lbs.

In this connection I may point out that the manufacture of morphine has been monopolised by the Indian Government to themselves only, which is contrary to the usual practice adopted in more advanced countries of the west. In Great Britain and in U.S.A. the manufacture of opium alkaloids has been allowed to private industries and it is desirable that a similar practice be adopted in this country also with similar necessary Government supervision and restrictions to prevent illicit use. This matter has been several times placed before the Indian Government individually as well as through trade associations, Commerce Chambers, Federation of Commerce and Industries, Baroda Government and various other bodies, but all these public appeals have so far failed to move the Government attitude otherwise. The Government monopoly in this respect continues to perpetuate a feeling of inferiority complex and unfavourably tells upon the ethical integrity of the chemical manufacture of this country in the international eyes. I therefore would like that the panel should study the whole case as has been so far put before the Government at various occasions and offer its critcisms in the matter as to the advisability or otherwise of permitting the manufacture of Opium alkaloids to private agencies in India in manners similar to those prevailing in Great Britain or U.S. America.

Quinine.—(Target production 20,00,000 lbs. per annum.)—Quinine is the alkaloid obtained from Cinchona bark. The percentage of Quinine in various species of Cinchona varies very much and may range from 1·5 to 4% or higher. Taking an approximate yield of 2·5 percent of quinine, the annual requirement of the cinchona bark for the production of 20,00,000 lbs. of Quinine per annum is 80,000,000 lbs.

Strychnine.—(Target production 3,000 lbs. per annum).—Strychnine may be obtained from Nuxvomica seeds. It occurs in nuxvomica seeds to the extent of about 0·8 to 2·5 percent. Based on an approximate yield of 1·5% strychnine, the quantity of Nuxvomica seeds annually required for the yearly production of 3,000 lbs Strychnine is 2,00,000 lbs.

Location of alkaloid industry : General observations.

(1) *Location of the manufacture of alkaloids.*—So far as the manufacture of Alkaloid is concerned, it is only a small section of the fine chemical industry. The manufacture of alkaloids chiefly concerns the galenical and pharmaceutical industries. Except for the production of Morphine and Quinine (the former being legally forbidden to be manufactured by private industries in this country and the latter being not possible on account of the unavailability of the Cinchona bark at competitive rates and the government being interested in its manufacture) all the remaining four alkaloids are manufactured at present on smaller scales in the existing galenical and pharmaceutical industries of this country, the question of larger production of alkaloids to achieve the target means expansion of the existing production. In the manufacture of alkaloids, besides the crude drugs, large quantities, of other processing requisites such as alcohol, benzene, ether, Chloroform and other solvents alkalis and acids etc., are also required and consideration of their transport to the place of manufacture is very important. The small advantage of saving in transport of the crude drugs which can be achieved by manufacturing alkaloids at places where crude drugs grow will be far outweighed by many such disadvantages. Further, the technical supersvision, establishment and running charges, equipment, trading and distribution facilities will be more favourable in the large pharmaceutical and galenical industries than what can be economically expected in different independent separate alkaloid manufacturing schemes as these are only very small partial activities of the larger galenical and pharmaceutical industries and as such can be handled with greater economy in producing and overhead charges and greater conveniences. Therefore, if considered from all visions, it is not necessary to carry out manufacture of the alkaloids at the places where crude drugs grow ; in fact, the location of manufacture of Alkaloids is immaterial if it is carried out by competent large galenical and pharmaceutical industries.

(2) I understand Russia and many advanced countries provide facilities for special cheap transport of crude drugs for manufacturing purposes ; it is desirable that in order to stimulate growth of the fine chemical and pharmaceutical industries in this country threatened with keen foreign competition, the Indian Government should provide for very cheap transport of the crude drugs, essential technical heavy chemicals, solvents and several such articles required for manufacturing and processing purposes by the pharmaceutical and fine chemical industries. The Government also should extend protection to these industries by proper Tariff formulation to prevent undesirable dumping of foreign goods affecting adversely local production. Also exemption from Government duties and taxes should be granted to those raw and technical materials which are liable to such taxes when they are required for manufacturing and processing purposes by industries.

APPENDIX I (*b*).

SUPPLEMENTARY REPORT ON GALENICALS, ALKALOIDS, ETC.

(*By Mr. N. Adhikari*).

Galenicals.—

The all India consumption of spirit for the manufacture of Galenicals is about 4,00,000 L.P. gallons per annum besides that consumed by the Government factories at Bombay and Madras and the total value of the different kinds of equipment in use for this purpose amounts approximately to Rs. 3,00,000.

Taking the target production of Galenicals at the end of 15 years to be five times as much as the present all India figure (besides the quantities manufactured in the Government factories) nearly 20,00,000 L.P. gallons of spirit will be necessary annually and proportionately about Rs. 15,00,000 will be required for capital goods of which 10% is to be imported.

As regards the list of equipments please refer Mr. Amin's report.

Alkaloids.—

To produce the different kinds of alkaloids mentioned in Mr. Amin's report to the extent decided upon namely—Caffeine-30,000 lbs. per annum ; Ephedrine—5,000, lbs. per annum ; Emetine—2,000 lbs. per annum ; Morphine—3,000 lbs. per annum ; Quinine—20,00,000 lbs. per annum and Strychnine—8,000 lbs. per annum—45,000 gallons of Commercial Benzene, 10,000 gallons of Naphtha, and about 4,000 gallons of petrol with equal quantities of Chloroform and Ether will be required per annum. The quantity of Batching oil required for quinine extraction could not be given but since the loss of solvent in the manufacture of this alkaloid is practically nil annual replenishment therefore need not be considered. Principal solvent for Morphine is water and the small quantities of others will be available from provisions already made.

Capital expenditure for the manufacture of the alkaloids mentioned in the report except Quinine will amount to Rs. 6,00,000. This figure does not include the cost of buildings, manufacturing sheds, storing vessels and jars.

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APPENDIX II.

A NOTE ON THE MANUFACTURE OF SULPHA DRUGS IN INDIA.

(Dr. K. Ganapathi, D.Sc. and Lt. Col. S. S. Sokhey, I.M.S.)

1. *Importance of the Sulphonamides.*—The sulphonamides now occupy a pre eminent position in the treatment of numerous bacterial infections against which very little could be done previously. In fact, sulphonamides with penicillin and atebrine can take care of more than three-fourths of all the major illness that afflict India.

To the question whether the advent of penicillin will displace the sulpha drugs, the answer is definite. From the therapeutic point of view, pencillin is an effective supplement but not a substitute for the sulphonamides. The modes of action of these two classes of drugs are dissimilar and their spectre of therapeutic activity are not exactly the same though they overlap in certain regions. Actually, in the antibiotics we are primarily looking to cover the regions wherein sulpha drugs are of no use. Further the sulpha drugs, unlike penicillin and other biological products are very stable and can be stored almost indefinitely. Because of this property, sulpha drugs will be the drugs of choice for use in the rural areas of India. The use of penicillin will be limited for long to urban areas.

The sulpha drugs have revolutionised the treatment of bacterial diseases and can be used in the treatment of some of the deadly epidemics which decimate India. Therefore, these drugs must be produced on a large scale and made available at the lowest possible cost to permit of their being used for mass treatment. Because these drugs will be used largely by the poorer sections of the community, their cost becomes a vital factor For these reasons, their production by the State becomes essential to eliminate the private profit element which usually makes up the largest part of the selling price of drugs. As shall be shown below, from the combination of a set of fortunate circumstances the State is in a particularly favourable position to take up their manufacture.

2. *Sulpha drugs that require to be manufactured in India.*—In a race to discover better and better drugs, nearly 3,000 sulphonamides have been synthesised and studied. Of these, only the following drugs have been selected for and given clinical trials:—

Prontosil
Prontosil Soluble
Proseptasine
Soluseptasine
Sulphanilamide
Albucid (N^1—acetyl sulphanilamide)
Irgamide (N^1—dimethylacroyl sulphanilamide)
Irgafen (N^1 —3 : 4 dimethylbenzoyl sulphanilamide)
Uleron
Sulphapyridine
Sulphathiazole
Sulphathiadizole
Sulphadiazine (2-Sulphanilamido pyrimidine)
Sulphamerazine (2-Sulphanilamide-4-methylpyrimidine)
Sulphamethazine (2-Sulphanilamide-4 : 6 dimethyl-pyrimidine)
Sulphapyrazine (2-Sulphanilamidopyrazine)
Sulphaguanidine
Sulphasuxadine (N^4-succinglsulphatiasole)
Sulphaphthalidine (N^4-phthaloylsulphathiazole)
Promin (A derivative of 4 : 4′-diaminodiphenylsulphone)
Diasone (Diformaledehyde sulfoxylatederivative of 4 : 4′ diamonodiphenylsulphone)
Promin (5′-p-aminobenzene sulphonyl-2-aminothiazole)
Marfanil (p-Sulphonamidobenzylamine hydrochloride)

It is not necessary to discuss the relative merits and demerits of all these drugs. It would suffice to say that, on the basis of the pharmacological and clinical data that have been published, the seven drugs, sulphanilamide, sulphathiazole, sulphadiazine, sulphamerazine, sulphamethazine, sulphapyrazine and sulphaphthalidine, are the best available to treat all the infections amenable to the sulphonamides taken as a whole. It is to be noted that sulphapyridine has been replaced by sulphathiazole and sulphadiazine. Both these drugs are, to be preferred to sulphapyridine. Of these, three drugs, sulphadiazine, sulphamerazine and sylphamethazine, belong to the pyrimidine group, but there appear to be slight difference between their pharmaeological actions. Which of these is to be chosen or whether all the three are required, has not become yet clear. The drug sulphamethazine has been suggested to be of advantage for use in the tropics because this causes practically no renal complication. The methods of manufacture of sulphadiazine and sulphamerazine are very similar while that of sulphamethazine is different from the other two. So, in this note, sulphamerazine has been left out from consideration. Sulphapyrazine will indeed ba a very valuable drug but the method of its manufacture at reasonable prices has not yet been perfected. Promizole (which appears to displace promin and dissone) and marfanil have not yet established themselves in clinical practice; so, these have not been included in the list of the drugs to be manufactured immediately. The chances of discovering a sulpha drug distinctly better than the seven mentioned above with all-round advantages are indeed remote. In conclusion, the following five drugs should be taken up for manufacture :—

Sulphanilamide,
Sulphathiazole,
Sulphadiazine,
Sulphamethazine and
Sulphaphthalidine.

3. *Targets for Production.*—Because of the want of the requisite data it is difficult to calculate exactly how much of the sulpha drugs would be required to deal effectively with medical and public health problems of India. However, the target suggested, *viz.*, **500,000** lbs. per annum, appears to be reasonable. The exact quantities of the sulpha drugs produced in U. S. A. are as follows :—

1937	355,369 lbs. of sulphanilamide
1938	338,939 lbs. ,, ,,
1939	709,148 lbs. ,, ,,
1940	543,802 lbs. of sulphanilamide 102,196 lbs. of sulphapyridine 91,907 lbs. of sulphathiazole
1941	(figures not obtainable)
1942	5,434,427 lbs. of all sulpha drugs put together.
1943	9,860,333 lbs. ,, ,, ,,
1944	4,597,050 lbs. ,, ,, ,,

These figures should be carefully interpreted to calculate the requirements of India. We cannot extrapolate these figures on the population ratio between the two countries to arrive at the target of our production. The period upto 1938 were years of experimentation for sulphanilamide and the years 1939 and 1940 for sulphapyridine and sulphathiazole. The steep rise in production in 1942 is the result of the Pearl Harbour incident. In the years following, U.S.A. almost single-handed produced practically all the sulphonamides required for the armies of the Allies and the World market. In a way, the figure given under the year 1943 may be taken to indicate roughly the world demand. Competition from penicillin is being felt from the middle of 1944. When we take all these into consideration, the target of 500,000 lbs. per annum for the production of the sulphonamides is reasonable. The quantities of the individual drugs to be produced in accordance with the demand could be taken as follows :—

Sulphanilamide	100,000 lbs.
Sulphathiazole	100,000 lbs.
Sulphadiazine	150,000 lbs.
Sulphamethazine	100,000 lbs.
Sulphaphthalidine	50,000 lbs.

Patent position regarding the manufacture of these drugs in India.—

This is a very important question in undertaking the manufacture of the drugs. Fortunately, in the present case, the position is quite happy. The Haffkine Institute holds seven patents covering the processes of manufacture of the sulpha drugs and their intermediates. We can now undertake the manufacture of all the drugs we require by an arrangement with Haffkine Institute, which is a Govt. Institution.

The usual processes for the manufacture of sulphanilamide are not covered in patents so we are free to manufacture this drug. Regarding the manufacture of sulphathiazole two methods are commercially feasible. One of the processes is covered in India by two patents held by Messrs. May and Baker. The other process, which is of great advantage specially under Indian conditions, has been covered in a patent held by the Director, Haffkine Institute. Two more patents regarding an improved method of preparing the intermediate 2-aminothiazole are also held by the Haffkine Institute. The process of preparing sulphaguadine by condensing acetsulphanilyl chloride with guanidine salts is covered in India by a patent of the American Cyanamide Company (U.S.A.). The alternative process of preparing the same drug by treating sulphanilamide with dicyandimide is open for exploitation, Sulphaguanidine as a drug for the treatment of the intestinal infection is effectively replaced by sulphaphthalidine. So sulphaguanidine has been left out from our list. Sulphaphthalidine is prepared very easily by treating sulphathiazole with phthalic anhydride. Two patents regarding the manufacture of sulphanilamidopyrimidine derivatives are held by the Haffkine Institute.

Thus, for the manufacture of the drugs contemplated, we need not depend upon the licence rights from foreign agencies. By an arrangement with the Director, Haffkine Institute, the manufacture of all the drugs required could be undertaken.

5. *Raw materials required and their availability.*—The question of the manufacture of the sulpha drugs of importance and the economics of the various processes, have been carefully studied at the Haffkine Institute, which has already made arrangements to produce about 8,000 lbs. of sulpha drugs. Based on this study, the raw materials required for the manufacture of the five sulpha drugs in quantities indicated, have been calculated to be as follows :—

Acetanilide	745,000 lbs.
Thiourea	115,000 lbs.
Guanidine nitrate	420,000 lbs.
Phthalic anhydride	26,000 lbs.
Pyridine (2°)	250,000 lbs.
Ethyl alcohol	600,000 lbs.
Methyl alcohol	100,000 lbs.
Acetone	250,000 lbs.
Ether (ethyl)	500,000 lbs.
Ethyl acetate	300,000 lbs.
Ethyl formate	200,000 lbs.
Sodium	80,000 lbs.
Chlorine	800,000 lbs.
Phosphorus oxychloride	670,000 lbs.
Zinc dust	700,000 lbs.
Calcium carbonate	700,000 lbs.
Decolorising carbon	5,000 lbs.
Chlorosulphonic acid	3,000,000 lbs.
Con. Hydrochloric acid	1,255,000 lbs.
Sodium Hydroxide	500,000 lbs.
Ammonia (as NH3)	30,000 lbs.
Total	11,246,000 lbs.

Of these items, ethyl alcohol, methyl alcohol, ether, chlorine, hydro-chloric acid, sodium hydroxide ammonia and calcium carbonate are available in India. One thing that requires to be emphasised and warned in the production of these raw materials in India is that much better attention has to be given as regards maintaining a standard quality and keeping the price at competitive levels. Some of the products prepared and supplied by the local manufacturers were found to be very disappointing in both these respects. The reason appears to be that the manufacturers are not able to adopt the modern and efficient methods of production for lack of suitable equipment but have to be satisfied with producing something with what they have got in a hotchpotch manner. The net result is that we have got to plan anew the production of the raw materials which can compete as regards quality and price with those available from U.S. A. or U.K.

Taking the prevailing market prices in U.S.A., the total cost of the raw materials listed works out to roughly 50 lakhs of rupees. Thus the cost of the raw materials for the manufacture of 1 pound of the sulpha drug, on an average, is Rs. 10.

6. *Equipment required.*—The manufacture of the sulpha drugs on the scale contemplated requires very modern equipment. It involves the handling of some of the most corrosive chemicals and some of the processes have got to be controlled with great care. The special type of equipment required will have to be imported from abroad. The following is the list of the special equipment required to undertake the manufacture:—

1000 gallons, jacketed, glass-lined kettle with stirrer	2
500 gallons, jacketed, glass-lined kettle with stirrers	20
50 gallons, jacketed, glass-lined kettle with stirrer	12
1000 gallons, open, single-shell glass-lined tank	20
Glass-lined condenser	2
500 gallons, stainless-steel jacketed kettle with stirrer	6
200 gallons, stainless-steel jacketed kettle with stirrer	6
1000 gallons, stainless-steel mixing tanks with stirrer	15
500 gallons, single shell stainless steel open tank	2
500 gallons, stainless-steel jacketed open kettle	3
Glass-lined storage tank, 5,000 gallons capacity	10
Washing type, open delivery, stainless steel filter press to hold about 200 lbs. of filter cake	10
Close delivery, stainless steel filter press, steam heated, capacity 20 gallons/minute	6
Centrifugal filters with stainless steel baskets	6
Steam Controls	50
Recording thermometeres	50
Stainless steel valves for kettles	50
Porcelain valves for kettles	50
Porcelain extension pipings	—
Stokes vacuum pump, 100 cu. ft. capacity	4
Drying chambers (110°), capacity about 250 lbs.	6
Acid resistant centrifugal pumps, 20 gallons/mt. capacity	10
Stokes BB2 tablet making machine	10
Oscillating granulators	10
Drying chambers	10
Mixers (500 lbs)	10

To this list is also to be added the cooling compressor to give cold water, steam boilers, air compressors and vacuum pumps to give steam, compressed air and vacuum lines respectively.

The total cost of the special equipment listed would be roughly rupees 20 lakhs. And the whole of this equipment will require to be imported.

7. *Number of units recommended and their location.*—From the point of view of economy, it is advisable to have a single unit undertaking the manufacture of the entire quantity of the drugs mentioned. By this there would be effected some saving in overhead expenses and economy in equipment also. But for strategic reasons, it is preferable to have two units located at two convenient places. Each of the units should be organised so that they can take up, at the same time, the manufacture of the sulpha drugs, atebrine and penicillin. By grouping the manufacture of these three drugs there could be effected some saving in over head expenses and also by way of equipment.

Regarding the sites to be chosen for the location of the plants, the main considerations are the availability of the cheap electric power and facilities for the transport of the raw materials. The largest amount of raw materials used fall under the category of acids and alkali. The plants should be located near the plants producing chlorosulphonic acid, hydrochloric acid, sodium hydroxide and chlorine. Thus we can save the transporting of nearly 3,000 tons of dangerous chemicals.

Further since the manufacture of the sulpha drugs involves the handling of large quantities of chlorosulphonic acid, phosphorus oxychloride and sodium the plants should be located in places where the humidity is not high and the rainfall also is not heavy. These considerations should be given careful consideration when locations are being selected for putting up plants for the manufacture of chlorosulphonic acid, phosphorus oxychloride and sodium. The site for making these chemicals and sulpha drugs should be the same, or they should be near about and easily accessible.

8. *Satges in which progress should be made.*—The production of 500,000 lbs. of sulpha drugs annually is indeed a very responsible job. In India there exists no pharmaceutical industry producing synthetic drugs worth mentioning. For the production of sulpha drugs in quantities mentioned batteries of units have to be set up. To start with, we can attempt to produce about a third of the target aimed at and when considerable amount of experience is gained, the units could be multiplied to turn on to full production. Provided there is no bottleneck by way of nonavailability of equipment or raw materials, in about two years the full quota could be realised. We have got at our disposal the experiences of the American industrialists who can, it is reported, switch on at any moment to produce 10 million lbs. per annum.

To start with, we need not wait for the raw materials to be manufactured in India. While the production of the raw materials is being planned and given effect to, the production of the sulpha drugs could start with imported raw materials.

9. *Approximate costs of manufacture.*—The price of raw chemicals (American market price) works out at Rs. 50 lakhs for the manufacture of 500,000 lbs. of the drugs. Overhead costs and depreciation will work out to about 10 lakhs at the most. Thus the cost per lb. works out to about Rs 12/-. We do not expect it to exceed Rs. 15/- per lb.

10. *How the industry should be managed.*—The manufacture of sulpha drugs (and penicillin) is pre-eminently an activity which must be under-taken by the States. Firstly because Government is in a happy postion that all the necessary patents needed are Government owned. And secondly because these drugs are required for the mass treatment of epidemics and other bacterial infections largely among the poorer sections of the community, they must be available at the lowest possible cost. In private produced drugs, the private profit is the largest element in the cost. It has been shown that sulpha drugs in quantities given above can be made at an average cost of about Rs. 15/- per lb. If these be bought from the market the average price would be about Rs. 65/- per lb. No better argument is needed for the State to take up manufacture.

11. *The nature of technical advice and the assistance required.*—The manufacture of sulpha drugs (penicillin and atebrine) can be very largely taken up under our own steam without technical assistance from abroad, if we proceed the right way about it. It will be particularly easy to do so, as it is recommended that the production should be undertaken by the state itself. A small panel of about 4 men, who are engaged in the manufacture of these drugs and have acquired considerable experience of their nature, should be sent to America to contact equipment manufacturers and the producers of raw materials. They should have the power tentatively to place orders for equipment and raw chemicals. This throwing open of business to these firms would enable our panel to see the working of the plants and would enable them to secure the technical assistance of the makers of equipment to give every assistance for the installation of the plant in India. This technical assistance would be adequate to undertake the manufacture. With such a large order, it may be expected these firms would even send out their technical staff to erect the plant. But we are quite clear that engaging of any technical personnel from abroad for a long time would be quite unnecessary. All that requires is to make up our minds to go in for manufacture and give our panel a certain amount of authority to contact firms with the definite object of making concrete plans. It is to be added that these drugs are of a type that must get the highest priority and we should proceed with the manufacture as rapidly as possible. These drugs (sulpha drugs, penicillin and atebrine) between them would take care of more than 3/4th of the major illnesses that occur in India.

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APPENDIX III.

A Note on the Manufacture of mepacrine (Atebrin)

Dr. K. Ganapathi, D. Sc., & Lt. Col. S. S. Sokhey, I. M. S.

1. *Importance of Mepacrine.*—Malaria is the most serious of health problem of India. It is estimated by competent authorities that every year one hundred million attacks of malaria occur in India and a million deaths result from the disease. With the quinine source at our disposal *i.e.*, the quinine produced in India and imported from abroad, less than 1/8th of the cases of malaria received treatment at all. The rest remained un-treated. This urgent problem required immediate attention and cannot be met by any increased production of quinine in the near future, but fortunately we are no longer dependent on quinine. Atebrine (Mepacrine), which is an effective substitute for quinine, can be readily produced in sufficient quantities. Even when production of quinine is increased in India, atebrin will stay. Extensive experience gained during this war has shown atebrin to be distinctly superior to quinine in certain respects and has great advantages over quinine from a practical point of view. There is no doubt that atebrin has come to stay and if it is replaced at all, it will be replaced by a synthetic compound still more effective. Thus the production of atebrin should be undertaken immediately without any fear of the plant being thrown out of use.

2. *Target for production.*—The target of 500,000 lbs. per annum suggested for the production of mepacrine is reasonable. With this amount, we should be able to meet effectively the demands for the antimalarials. When Java was cut off and the Allied armies had to fight in the Eastern theaters of war mepacrine proved an effective substitute for quinine. The biggest supplier of mepacrine was the Winthrop Chemical Co. (U. S. A.), which in 1943, produced 466,406 lbs. of this drug and sold at $ 12.30 per lb. This quantity must have been largely used in the Indian, Burman and Pacific theatres.

3. *The Patent position.*—The process of manufacture of mepacrine is covered in India by a patent of the I. G. Farbenindustrie (Germany). The drug is now manufactured under licence rights granted by the Controller of Patents in his capacity as the Custodian of the Enemy Patents. The Haffkine Institute has been granted licence for the manufacture of mapacrine and has secured the raw materials and put up pilot plants for manufacturing about 3,000 lbs. of mepacrine. The purpose is also to study the comparative merits of the various alternative processes of manufacture that are possible. This study may evolve improvements in the process of manufacture.

4. *Raw materials required.*—The manufacture of 500,000 lbs. of mepacrine per annum is indeed a very responsible task. It is the most difficult of the drugs to manufacture, involving fifteen steps. It is also very exacting as regards the requirement of raw materials and special types of equipment. There are a number of alternative methods possible, which differ from one another as regards the requirement of special chemicals, equipment or application of particular reaction conditions. We have got to make up our mind as regards the processes we are going to adopt by surveying the raw materials which we can produce and the equipment we can obtain. The quantities of chemicals which may be required for the manufacture of 500,000 lbs. of mepacrine by two alternative processes have been calculated to be as follows.

Chemical.	Process I	Process II
Para nitrotoluene	450,000 lbs.	...
Acetanilide	..	750,000 lbs.
Pa-ra anisidine	300,000 lbs.	300,000 ,,
Phenol (Pure)	650,000 ,,	650,000 ,,
Diethylamine	255,000 ,,	400,000 ,,
Ethylacetoacetate	850,000 ,,	425,000 ,,
Ethylene oxide	275,000 ,,	200,000 ,,
Hydroxylamine hydrochloride	140,000 ,,	140,000 ,,
Acetone	1,850,000 ,,	1,850,000 ,,
Dichlorethylene	600,000 ,,	600,000 ,,
Butyl alcohol	1,400,000 ,,	1,400,000 ,,
Ethyl alcohol (absolute)	500,000 ,,	500·000

Benzene	250,000	lbs,	250,000	lbs.
Ether	500,000	,,	1,000,000	,,
Acetic acid	..		4,000,000	,,
Chlorine	300,000	,,	750,000	,,
Phosphorus oxychloride	600,000	,,	600,000	,,
Thionyl chloride	..		600,000	,,
Sodium metal	425,000	,,	380,000	,,
Copper sulphate	100,000	,,	600,000	,,
Sodium bisulphite	150,000	,,	750,000	,,
Sodium chloride	300,000	,,	..	
Sodium cyanide	..		600,000	,,
Sodium dichromate	1,050,000	,,	..	
Sodium nitrite	200,000	,,	350,000	,,
Anhyd. Potasium carbonate	425,000	,,	425,000	,,
Potasium acetate	3,000	,,	3,000	,,
Sodium bromide	1,125,000	,,	..	
Anhyde. Calcium chloride	250,000	,,	250,000	,,
Copper powder	5,000	,,	..	
Iron filings	575,000	,,	..	
Decolorising carbon	10,000	,,	10,000	,,
Sodium hydroxide	2,750,000	,,	2,750,000	,,
Con. Sulphuric acid	4,300,000	,,	2,000,000	,,
Con. Hydrochloric acid	2,500,000	,,	4,000,000	,,
Con. Hydrochloric aied C. P.	500,000	,,	500,000	,,
Ammonium hydroxide (25%)	1,250,000	,,	2,000,000	,,
Total	26,333,000	lbs.	28,793,000	lbs.

Of the chemicals listed above, considerable amounts of the solvents, acetone, dichlorethylene, butyl alcohol, ethyl alcohol, benzene and ether could be recovered and used again.

We are not discussing here the number of problems that arise in the choice of the methods to be employed in the manufacture of 2 :4—dichloro—benzoic acid and the side chain. As regards these, two things we have got to keep in mind. In the first place, we should always prefer the method which, from the point of view of working, is safe and attended with the least amount of accidents and danger. Secondly, the chemicals and the intermediates to be handled should not annoy the workers and affect their health by constantly dealing with them for a long time.

The manufacture of 500,000 lbs. of mepacrine requires a good deal of coal tar products. For the preparation of para nitrotoluene required, we require about 100,000 gallons of toluene which is about 1/5 of the total production of toluene in India. In the alternative process, which is found to be attractive from the point of view of working, para nitrotoluene is avoided and acetanilide takes its place.

For the production of the quantities listed of acetanilide, phenol, para anisidine and diethylamine (which is to be prepared from diethylaniline to obtain a product of reliable quality), we require about 250,000 gallons of benzene.

The manufacture calls for large quantities of the solvents :—acetone, dichloroethylene, butylalcohol, ethyl alcohol benzene, ether and acetic acid, to the extent of nearly 5,000 tons.

Of the heavy chemicals, the production of sodium, phosphorus oxychloride and thionyl chloride requires to be organised for the first time in India. As regards others, the remarks made in the note on the manufacture of the sulpha drugs should be considered.

5. *Equipment required.*—The difficulty in the manufacture of mepacrine arises not because of the large number of steps to be gone through but because some of the steps involve processing operations that are hazardous to be undertaken on large scale. To

produce 500,000 lbs. of mepacrine we have got to handle nearly the equivalent amount o sodium or nearly half a ton of sodium per day. Some of the intermediate products are very irritating to the skin and mucous membrane. Before drawing up the plan, it is absolutely assential that the experiences of the manufacturers of mepacrine in U. K., U. S. A. and Russia should be carefully taken into consideration and the layout and equipment decided with the advice of all. This will save us a lot of trouble and avoid possible break-down. An attempt has not been made, therefore, to draw up a list of the equipment required for the manufacture of mepacrine. The nature of the equipment will be of almost the same type as those required for the manufacture of the sulpha drugs, but quantitatively it will be twice as much. Roughly, the cost of the equipmet will work out to Rs. 40 lakhs. Practically all of the equipment will require to be imported.

6. *The cost of production of mepacrine.*—On the basis of the latest American market prices, the cost of the chemicals listed for the manufacture of 500,000 lbs. of mepacrine works out to Rs. 90 lakhs. The overhead and running expenses per annum will be about Rs. 10 lakhs, so that for manufacturing 500,000 lbs. of mepacrine the total cost works out to Rs. 100 lakhs. Thus one pound of mepacrine will cost Rs. 20
The American price is $. 12·30 per lb.

7. *No. of units required and their location.*—As was recommended in the note dealing with the sulpha drugs, it is preferable to have two units to turn out the quantity of mepacrine contemplated. These two units should preferably be in the same place wherein the manufacture of sulpha drugs are to be undertaken. By this, there will be some saving in capital expenditure.

As regards the location of these two units, the same recommendations made as regards the sulpha drugs hold good.

8. *Stages in which the progress is to be made.*—Since the large scale manufacture of mepacrine is an extremely difficult task which requires very well-trained personnel to undertake, we should, start with producing about a tenth of the target and then gradually increase the production by multiplication of the units possibly in the course of five years.

9. *Nature of technical assistance required.*—The present is a very fortunate moment for taking up the production of mepacrine. We are reliably informed that the United States of America is stepping down its production and that certain plants will become surplus. We have the choice of visiting these plants and deciding for ourselves whether they would meet our purpose. This will have the further advantage that we will be buying machinery actually in working order and this will also enable us not only to buy the plant but also come to know of the actual details of production, because people who sell the plants will have to explain the issues. But this advantage can be gained only if immediate action is taken. For this purpose, as suggested in the sulpha drug note, a committee of 2 or 3 men who have actual experience of production and are not connected with commercial firms (the reasons for this will be given later on) should be sent abroad immediately to visit plants in U. K., America and particularly Russia. The Haffkine Institute was invited by the Russian Society Voks some time ago to send some workers to Russian plants that produce mepacrine and they promised to give every facility for practical learning of the methods of manufcture. This is a particularly attractive help and should be made use of. We are sure that we could get a group of chemists and others who are actually to run the plant and would be trained in Russia, if facilities were not available elsewhere. The thing would be to start with one plant with output of about 50,000 lbs. a year and use that both for training more men and deciding the best means of manufacture for further development.

10. *How this industry should be managed.*—Malaria is unquestionably a problem for the State to tackle, and so naturally Government should take up the manufacture of mepacrine. The drug must be made available to the health authorities at the lowest possible cost. And this can be done only by eliminating the private profit element.

APPENDIX IV.

A NOTE ON MANUFACTURE OF PENICILLIN IN INDIA.

Dr. K. Ganapathi, D. Sc., and Lt. Col., S. S. Sokhey, I. M. S.

1. *Importance and Requirements of Penicillin.*—Penicillin is one of the most important drugs of the day and it has a wide application for the control of the infections due to gram positive bacteria. In addition , its value in the treatment of syphilis is proving to be of particular interest. At present, penicillin is not being widely used in India because it is not available, it is very costly and has to be administered by hospitalizing the patient. Only the rich are able to have the benefit of this drug. If we take it that roughly 4 million cases require to be treated with penicillin per annum, our annual requirements would work out to about 3,000,000 million units of penicillin. So far, penicillin is being given by injection every three hours round the clock to conserve the material which is both unavailable in large quantities and at the same time very costly. This administration of penicillin by frequent injections is one of the most annoying features of penicillin therapy and requires Hospitalization of the patient. So though 4 million cases may require penicillin, we, may not be able to treat this number for lack of hospital facilities at present. With the availability of more penicillin and at cheaper rates, the oral administration under suitable conditions would possibly be taken up. This method of administration would require about five to ten times the amount of penicillin to produce the same effect as obtained by injections.

To meet our future requirements, we should aim at producing about 1,000,000 million units of penicillin per annum. But we can make a small beginning and then gradually increase the production in the course of time. In fact the production of penicillin by 21 firms in U. S. A. started on a small scale, is increasing day by day in the geometrical progression as the following figures show :—

Month and Year.	Penicillin produced in U. S. A.	
June 1943	425 million units.	
July 1943	762 ,, ,,	
August 1943	906 ,, ,,	
......	......	
January 1944	12,550 million units.	
February 1944	18,726 ,, ,,	
March 1944	31,192 ,, ,,	
April 1944	74,964 ,, ,,	50% of this produced by one firm.
May 1944	94,132 ,, ,,	
June 1944	117,527 ,, ,,	
January 1945	394,000 ,, ,,	
February 1945	405,000 ,, ,,	
March 1945	460,000 ,, ,,	

In the course of two years, the production has increased by thousand times. In the year 1944, U. S. A. produced 1,663,300 million units of penicillin costing $, 35,000,000. In 1945, the production will be about 5,000,000 million units which will cost about $ 75,000,000. The price has also dropped down considerably ; from $ 20·00 it has come down to —$. 1·56 per 100,000 units.

The U. S. A. Government bought penicillin from the manufacturers at $ 0·56 per 100,000 units. The increase in production observed is not so much due to the expansion of the plants as by the improvements of effected in the methods of production. Of the 21 firms engaged in the production of penicillin in America, one firm alone produces 30%

of the total output. Chas Pizer & Co., has stepped up production to 175,000 million units per month. In England, recently, a plant was erected at Spake near Liverpool at a cost of about £1,250,000 and with the capacity of 100,000 million units per month by the Ministry of Supply.

2. *Present fermentation method of production versus synthetic penicillin.*—So far, no method for synthesising penicillin has been found. But there is little doubt that, at some future date which may be the near future or decades hence, one will be invented and when that happens, Penicillin will naturally be produced synthetically. The present selling price of $ 11,250 per lb. of penicillin produced by the fermentation method would, very likely, fall to $. 500 per lb. when produced synthetically. This estimate is based on the fact that no synthetic chemical, however difficult and complicated the process of preparation may be, costs more tan $ 500 per lb. In this connection the example of thiamine is very illuminating.

In 1935, it was produced from rice bran and sold at $. 135,000 per lb., to day in U. S. A. about 50 tons are being manufactured synthetically per annum and are being sold at $. 80 per lb. Even riboflavin is being produced at the rate of nearly 60 tons per annum costing $. 100 per lb. The same thing quite possibly will happen to penicillin. This possibility is indeed quite familiar to all the producers who have put up penicillin plants but they do not appear to have headaches over this because the plants could be turned on for the production of other products of fermentation and also other biologicals. Economically, penicillin plants will never be a loss for the simple reason that plants costing 20 million dollars produce enough penicillin to be sold for 75 million dollars in one year. So far as the pharmacetuicals are concerned we should not allow future possibilities in other directions to shelve off immediate necessities, So, whatever will be the position in future if synthetic penicillin becomes a reality, we should not postpone undertaking the manufacture of penicillin by the present fermentation process adopted all over the world at present. Even if, in future, penicillin is likely to be superseded by some other synthetical just as the sulpha drugs have thrown prontosil into the background, our duty at present is to go with the manufacture of penicillin.

3. *The stages in which the production is to be organised.*—It is very necessary that we should turn on to full production of penicillin in India. But three important factors impose some limitations in our efforts. In the first place, the production of penicillin is a highly specialised task which involves the unique combination of the bacteriological, chemical and engineering techniques. Secondly, we require highly specialised types of equipment. Thirdly, we require large amounts of organic solvents and chemicals. Therefore, we should make a small beginning and go on expanding till we meet the demands. To start with, one plant with a capacity of about 10,000 million units per month should be erected. The capacity of the plant could be increased gradually and another plant also erected as the situation regarding the availability of plants and raw materials improves.

4. *The methods to be adopted.*—There are two methods of production of penicillin which are commercially practised, namely, the surface culture method and the submerged growth method. The first is the oldest and the safest one but the great drawback about it is that it is not suitable for productions beyond 10,000 million units per month. To produce this amount, we have got to work up every day 50,000 bottles, these have got to be cleaned, filled with the media, sterilised, inoculated incubated and the cultured fluid drained out asceptically.

The labour involved is enormous. On the other hand, the submerged growth method is well suited for the large-scale production and it is this method which is adopted by all the biggest producers. There is a great saving in labour but the engineering side takes the upper hand. We have to obtain huge fermentors which can work under aseptic conditions and also aerated without causing any contamination with the air-borne organisms. It is quite easy to step up production with this method. The Commercial Solvents Corporation (Indiana) uses fermentation tanks of capacities of 12,000 gallons. The plant of the Suibb and Sons also appears to be using fermentors of 15,000 gallons capacity.

5. *The raw materials required.*—To produce 1,000,000 million units of penicillin by the submerged growth process, the following chemicals are required in quantities mentioned :—

Lactose (Commercial)	1,500,000 lbs.	
Magnesium sulphate	20,000 lbs.	
Potassium dihydrogen phosphate	40,000 lbs.	
Sodium nitrate	240,000 lbs.	
Zinc sulphate	750 lbs.	
Acetone	1,200,000 lbs.	Recoverable.
Amyl or butyl acetate	1,000,000 lbs.	
Choloroform	50,000 lbs.	
Phos-phoric acid (75%)	10,000 lbs.	
Sodium bicarbonate	20,000 lbs.	
Activated charcoal	300,000 lbs.	
Alumina (activated)	....	
Corn steep liquor (con.)	350,000 gallons.	
Bacto-peptone	500 lbs.	
Bacto-yeast extract	100 lbs.	
Agar	500 lbs.	

Lactose need not be of high quality and it is best made from the skimmed milk or milk powder by removing off casein. It could be substituted for a time by brown sugar or jaggery.

6. *Equipment required.*—Highly specialised types of equipment are required for the manufacture of penicillin. To produce 1,000,000 million units per annum, 25,00 gallons of the culture fluid has got to be made and worked up per day. Since the mould is allowed to grow under aeration for 3 days, at a time the plant should be able to accommodate nearly 125,000 gallons of the culture fluid in the fermentation tanks, the number and capacitie of which have to be decided in consultation with the experts who have worked with them. The separation of the mould is made by filtration, the pencillin secreted is absorbed on activated charcoal which is separated by filtration, washed and then eluted with acetone or with other solvents. Now huge volumes of liquids representing one-tenth of the original have to be centrifuged with the aid of Sharples supercentrifuges. After purification by partition between solvents, the final product, after Seitz filtration, is to be dried by the lyophilic method. Without going into the number and quantities required, the equipment required is given below to give a rough idea.

Glass-lined fermentation tanks, fitted with heating and cooling coils, arrangement for blowing sterile air and temperature controls.

Sterile air generating equipment.

Glass-lined stills

Centrifugal filters.

Plate and frame filter presses.

Sharples supercentrifuges (penicillin centrifuges)

PH. controls

Lyophilic drying equipment

Solvent recovery plants.

Bottle washing machines.

Bottle filling machies.

Bottle closing machnies.

'Toledo printweigh' weighing machines.

Refrigerators kept at —40°C.

Air conditioners.

The cost for the erection of all the penicillin plants in U. S. A., which produce 5,000,000 million units of penicillin per annum has been estimated to be about 8 crores of rupees. The plant at Liverpool which is to turn out 1,200,000 million units of penicillin per annum costs about 2 crores of rupees. The cost of one plant with a starting production capacity of 10,000 million units will be about 25 lakhs of rupees. The quantity of penicillin produced by this plant at the present American market price, which is less than half the selling price in India will bring in a revenue of 75 lakhs. So the return even to begin with is much more than the initial investment. Instead of India buying penicillin from abroad, she can very well put up the plant and produce her own penicillin.

7. *How the Industry is to be managed.*—Penicillin is a product which took shape within a record time mainly because of Government encouragement and priorities. As a principle, the drugs that are of vital importance should be produced by the Government in as large a quantity as possible and at the lowest possible price. The American market price of penicillin which we have spoken of is 2/3 profit. The drug is sold to the public at $ 1·56 per 100,000, while it is sold to U. S. A. Government at 56 cents. It may be taken that private firms do not sell at a loss to Government. Thus, if the drug is produced by Government, the cost to the hospitals and other buyers will be about 1/6th of the present Indian selling price.

8. *Technical advice required.*—In the production of penicillin, there are a number of practical details that have got to be examined before deciding our methods of production. It will decidedly be not the correct procedure to contact some firm abroad and then request them to put up a plant or two here. The commercial production of penicillin is going on at a terrific rate in U. S. A. during the past two years and by now each firm engaged in the production has gathered a good deal of experience. The details of the growth of the mould, the methods of recovery of penicillin, the methods of drying adopted etc., are not exactly the same. Each firm adopts the method that suits its convenience as regards the availability of raw material and equipment. This individual differece in processes is reflected in the quality of the products put on the market some assaying 150 units per mg. of the dried material and some as high as 1200 units per mg.

The correct way for us to proceed on is to appoint a panel of competent men in the line to visit the various plants in U. S. A. & U. K. and Canada, also contact the War Production Board (U. S. A.) which has been subsidising a large amount of research in this direction and then decide, after carefully examining the information available and provided, which would be the best methods for us is India to adopt. Only after this, we should approach, through the panel, the prospective manufacturers of the suitable plants for getting equipment for our purpose. There is no use putting up plants in India on the discarded 1943 models.

APPENDIX V.

Some Recommendations regarding the manufacture of Sulpha Drugs, Mepacrine and Penicillin.

Dr. K. Ganapathi, D. Sc. and Lt. Col., S. S. Sokhey, I. M. S.

1. *The priority they should get for manufacture.*—The sulpha drugs, mepacrine and penicillin, are of very great importance for the treatment of the infections that afflict humanity. As pointed out previously these drugs can take care of nearly three-fourths of all the major illnesses that cause death and disablement in India. So, the production of these should get practically the first priority. The cure of infectious diseases come next only to the question of food.

2. *Two units for the production of all the durgs.*—It is recommended that these drugs be produced in two units, each of which would be a co-operation consisting of plants for the production of sulpha drugs, mepacrine and penicillin. The manufacture of these drugs requires the handling of large quantities of organic chemicals and solvents. The solvent recovery process to be carried out in the course of the manufacture of these drugs will practically be the same. The aim in clubbing the production of these drugs in one corporation is to save by way of capital and running expenditure, to have greater adaptability as regards turn-over and also to allow some degree of manouevre in chemical processes. A big unit is in a better position to stand the shock due to unfavourable economic situation and also withstand competition from outside. This is one of the main reasons why the small concerns are grouping into big corporations in America.

As regards the location of the two units, one could be located in the North and the other in the South in suitable places.

3. *The raw materials required.*—For the whole of the enterprise, the quantities of raw materials required to realise the full targets (*i.e.*, 500,000 lbs. sulphonamide, 500,000 lbs. mepacrine and 1,000,000 million units of penicillin per year) are as follows :—

Coal Tar Products.—	lbs.
Benzene	250,000
Acetenilide	1,500,000
Diethylaniline	1,200,000
Phenol	650,000
Para anisidine	300,000
Pyridine (20°)	250,000
Phthalic anhydride	26,000
i. Organic solvents and fine chemicals .—	
Ethyl alcohol	1,100,000
Methyl alcohol	200,000
Ethyl ether	1,000,000
Acetone	3,300,000
Butyl alcohol	1,400,000
Acetic acid	4,000,000
Chloroform	50,000
Dichlorethylene	600,000 (optional).
Ethyl acetate	300,000
Ethyl formate	200,000
Butyl or amyl acetate	1,000,000
Ethyl acetoacetate	600,000
Ethylene oxide	275,000
iii. Miscellaneous organic chemicals.—	
Thiourea	115,000
Guanidine nitrate	420,000
Lactose	1,500,000

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iv. Inorganic heavy chemicals and miscellaneous chemicals.—

	lbs.
Con. Hydrochloric acid	4,000,000
Con. Sulphuric acid	4,300,000
Chlorosulphonic acid	3,000,000
Phosphoric acid (75%)	10,000
Sodium hydroxide	3,250,000
Ammonium hydroxide (25%)	1,370,000
Chlorine	1,550,000
Sodium	500,000
Phosphorus oxychloride	1,270,000
Thionyl chloride	600,000
Sodium bromide	1,125,000
Sodium nitrite	200,000
Sodium nitrate	240,000
Sodium cyanide	600,000
Sodium bisulphite	750,000
Sodium dichromate	1,050,000 (alter)
Potassium carbonate	425,000
Potassium acetate	3,000
Potassium dihydrogen phosphate	40,000
Copper sulphate	600,000
Calcium chloride	500,000
Decolorising carbon (activated charcoal)	400,000

4. ***Economics of the processes.***—If we take the American market prices into consideration, we arrive at the following figures regarding the economics of the processes :—

	Rs. in lakhs.
The cost of all the chemicals required for the manufacture of the sulpha drugs, mepacrine and penicillin in quantities indicated	145
The cost of equipment, building and fittings to set up the two units	350
The running expenses of the two units	25
The cost of the drugs that will be produced by the two units taking into consideration the depreciation at 10% of the capital expenditure	205
The selling price of the drugs that will be produced on the basis of the American market (bulk) prices not including duty is approximately	820
The selling prices of the drugs on the basis of the present market prices in India is about	3,000

The above figures are given as rough indications for us to get an idea. Some of the figures have been calculated by the extrapolation of the quotations obtained in equipping the Haffkine Institute. The actual figures should be somewhere near this.

Throughout, we have taken the American market prices of the chemicals in calculating the costs. We are convinced that it is possible to produce the raw materials in India at competitive rates, if the Govt. takes it up and proceeds about in the right direction. The reason that has led us to this conviction is that even taking these selling prices in American market for the chemicals, we require for the manufacture of the sulpha drugs, mepacrine and penicillin, we may be able to produce the finished products on competitive levels. The figures justifying this have been given above which speak for themselves.

The drug industry should be started not merely for making India self-sufficient as regards her needs, but also to effect a great saving. What it would cost to put up the plants and run the units is much less than what it would to buy the drugs from the foreign markets. No better reason could be given to impress upon the necessity of starting this industry as early as possible.

5. *The stages in which the progress is to take place.*—The figures regarding the costs of chemicals and the units to be set up have been calculated to realise the full targets suggested. The full-scale production is to be realised in the course of ten to fifteen years and the production of these in India is closely linked up with the manufacture of the raw materials, and also the development of medical institutions to make use of these products. But an effective start can be made and production kept up with imported materials until the manufacture of the raw materials in India catches up the demand.

To start with we should plan to produce about one fourth to one tenth of the targets suggested and then increase production steadily as the position regarding availability of raw materials and trained personnel permit.

Under paragraph 11 in the Note on the sulphonamides, we have already stated how we should set about to plan the production of these important drugs. Before any executive action is taken, it will be necessary to produce more concrete and detailed plans which can then be passed on to the departments to undertake production. The drugs dealt with in these notes are of such vital importance that concrete plans, almost amounting to blue prints, should be prepared at the earliest possible and to this effect we have already referred to in the note on the sulphonamides.

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APPENDIX VI.

THE SHARK-LIVER OIL INDUSTRY.

Dr. V. Subrahmanyan and Mr. B. N. Banerjee.

A War-time effort that must be sustanined in the interests of the country.

During recent years, a great deal of interest has centred round the production of shark-liver oil, especially on the West Coast of India. A useful volume of scientific literature has also grown up on the subject. The object of this contribution is to review the present position and to indicate some of the lines along which the industry should be planned and organised not only for meeting the post-war needs of the country, but also for holding its own against foreign competition.

India had once a flourishing fish oil industry.

The fish liver oil is no stranger to India. About eight decades ago, India exported quite large quantities to the West, Calicut being a big centre of production. Around 1870, the price of Cod-liver oil fell below that of the Malabar fish oil and the Indian industry practically died out for want of a suitable market. Cod-liver oil from Norway and other countries began actually appearing on the Indian market in increasing quantities and the country became more and more dependent on foreign supply.

The German invasion of Norway, followed by British blockade, practically cut off that country from the rest of the World. The subsequent submarine Warfare and the increased demands of the other nations kept India in short supply of cod-liver oil. Against this, the demands of the civil population and the fighting forces in the country for some suitable source of Vitamin A, became quite considerable. An alternative source had to be found and, under this stress, the Malabar fish liver oil industry was reborn.

The high Vitamin A potency of Indian Shark-liver Oil.

A great deal of credit is due to the Government organisations, as also the co-operating scientists, who helped to start the industry. It was soon established that the liver oils from the shark and the saw-fish has a much higher Vitamin A potency than Cod-liver oil. Occasional samples have potencies of several hundred thousand International units per gram, *i.e.*, well over 100 times the potency of standard Norwegian Cod-liver oil. The average potency is however, of a lower order, though still, distinctly higher than that of cod-liver oil. In some areas, an average of 30,000 units has been reported. In others, over 10,000 is found to be the average. We have examined genuine samples having a potency of between 5,000 and 6,000 units. A minimum potency of 10,000 units per gram has been suggested for the Indian Addendum to the British Pharmacopoeia and this may not be difficult to attain in practice. An oil of this standard will have about six times the potency of average Norwegian Cod-liver oil.

According to the latest International standard, the average daily requirement of an adult would be about 5,000 units of Vitamin A. The majority of people in India get very much less than this quantity in their food. A large section of the population would require between 3,000 and 4,000 units as a supplement to make the required minimum. The supplement has to come in the form of fish liver oils, Vitamin or carotenoid concentrates etc., but very few actually get them. The majority go without it, with the result that gross deficiency manifests itself in different forms. Early blindness, tuberculosis and other wasting diseases are some of the ultimate consequences of such persistent deficiency. Apart from the millions who are thus afflicted, there are several millions more who show a subnormal condition. In fact, it is generally recognised that there is more extensive deficiency of Vitamin A than that of any other Vitamin in India.

A target for production.

Granting that about 10% of the population of India is to receive a supplement of 2,000 units per day of shark-liver oil (possessing an average potency of 10,000 units per gram), the total requirement of the Country would be roughly a million gallons. If we make some allowance for the inevitable increase in population during the next decade and for an increased consumption by the people, the anticipated target of production would be about 2 million gallons.

The present production.

It is difficult to assess correctly the present production of the oil in India. Part of the production is under Government auspices and part through private enterprise. The oil is not usually marketed as such, but in a diluted form. The Government requirement (including the requirements of the Army) may be placed at a million pounds of Oleum Vitaminatum possessing an average potency of 1,500 units per gram. This would correspond to about 15,000 gallons of oil with a potency of 10,000 units. Some quantity has been exported outside the country, to China and elsewhere. In addition to this, there is the internal market of the country, but its off-take is not likely to have been so large as that of the Government. In fact, it is known that many of the big producers supplied their oil exclusively to the Government. Allowing a liberal margin for everything, it is unlikely that the present annual production of shark-liver oil from all sources could be very much more than 35,000 gallons. Even this may be an over-estimate.

There is evidence to show that all the oil is not derived from genuine shark or saw fish. The Governments and some of the reputed distributors are exercising some control, but the others are not so particular. We have examined specimens of oil containing only about 300 units per gram. These have subsequently been traced on the civil market, in a further diluted form, as standardised shark-liver oil. Such products are quite worthless and it is regretable that quite large quantities of these have been imposed on the already deficient civil population. This kind of thing is inevitable when there is no adequate drug control. At the same time, it must be remembered that even the lay public will not be slow in realising that they have not benefited by the use of such oils. There will inevitably be a reaction not only against the spurious brand, but other Indian makes as well, however genuine the latter might be.

It has already been mentioned that even genuine shark-liver oil may show considerable variation in regard to potency. This is due to a number of factors the most important among which are the season, the age and the size of the fish. The locality also seems to be a factor. The fish does not synthesize the vitamin, but only elaborates it from what it eats. The marine biologists have already collected a good deal of data bearing on these aspects; but in actual practice it is very difficult to apply them. The collecting and processing centres are far flung and it is not always possible to exercise the necessary control.

At the collecting centres, payment is made either on the basis of the weight of the liver or the volume of the oil. Both of these are defective. Payment should be on the basis of vitamin content, so that all concerned could aim at quality rather than quantity.

Indiscriminate fishing is harmful.

Some zoologists, keenly interested in the development of the industry, have expressed considerable apprehension in regard to the future chiefly because of the indiscriminate fishing that is going on. Even very young sharks, naturally, are being fast destroyed without any appreciable benefit. It has also been pointed out that the spawning seasons should be avoided for otherwise, the useful fishes will eventually disappear. It has, in fact been argued by some authorities that, at the present rate, it may be difficult to maintain even the existing supply. This may be undue pessimism, by any way the warning from such authorities has to be borne in mind when planning for the future.

The present methods require improvement.

At the present time, the industry depends largely on the efforts of fishermen who sell their material either to Government agents or to private contractors. The buyers either process the livers on the spot or, as more often happens to be the case, pack them in salt or other preservative and send them over to the factories for extraction of oil. Under the existing conditions, freezing would not be feasible. Even salt preservation should prove adequate, provided there is not much lapse of time between the catch and the preservation on one hand and preservation and extraction on the other. Normally putrefactive changes set in rapidly, liver being very readily attacked. The changes are naturally very rapid under the warm tropical conditions. Added to this, the liver is a store house of digestive ferments which, though classed as non-living, can yet produce very profound changes even in presence of the salt. Under the existing conditions, it is not uncommon to find a lapse of one to two days between different operations. This should be regarded as being too long. The oil increases in acidity, and putrefactive matter accumulates in the medium. On extraction, the oil is more smelly than it need be ; it also tends to go rancid on standing. The vitamin is also steadily destroyed, so much so, that under certain conditions, the oil becomes quite useless.

Need for protecting the vitamin.

The destruction of vitamin A in shark-liver oil has been studied carefully. The factors mentioned in the foregoing paragraph are very important in determining the rate of destruction. There are also other factors such as the nature of the container, diluent used, temperature, exposure to light, access to air and moisture and so forth. Even with the greatest care, it would not be possible to completely avoid destruction of vitamin. It is considered necessary, therefore, to add small quantities of protective agents (anti-oxidants) some of which are extremely potent in their action. Several anti-oxidants are mentioned in literature. Most of them are quite harmless at the concentrations to be used. They can be used singly or in certain combinations ; in the latter case, the beneficial effect is disproportionately increased (synergistic action). With such protection, the vitamin will remain stable for some years during which period the oil may be reasonably, expected to be consumed.

The use of anti-oxidants as vitamin A stabilisers is well known and extensively used. Many of the well known brands of Cod-liver oil preparations owe their substained quality to the use of such protective agents. Some imported brands do not of course contain them, with the result that their vitamin contents are not what they are claimed to be. In the interests of the Indian industry, it should be definitely made a policy to recommend and to insist on the use of the least harmful and the most effective among anti-oxidants.

The methods of collection and processing do of course require a good deal of improvement. Under the existing conditions, it will be difficult to introduce some of the improvements. If sufficienctly big vessels could be used and if the livers could be extracted on the vessels themselves as is generally the case in the preparation of cod-liver oil—a great deal of the subsequent difficulty could be avoided. Alternately, vessels fitted with refrigerating equipment could be used. This will require State support and organisation.

Potentialities are considerable.

India has a very long Coast line amounting to several thousand miles. Of this, only small part is actually being used for shark fishing. The possibilities of the rest of the coast —especially on the East—as also the use of other kinds of fish should be carefully studied. There will of course, be need to blend, but as long as this is done under proper scientific supervision, no harm will follow.

Even with proper organisation, it is too much to expect that the target of one million gallons a year can be attained in the near future. The supply of fish may not be adequate unless very special precautions are taken. In this again, state organisation will be needed.

Fish liver oil is the most potent source of Vitamin A. In a country like India, with its large vegetarian population, fish liver oil may not be acceptable to all. A considerable section of even strict vegetarians especially in South India—have no objection to the use of fish liver oil as a medicine. Even these would prefer a vegetable source, if available. The Jains and certain other communities have very strong objections to fish oils. In any case, fish liver oils will not meet the entire country's need. The carotenoid pigments from vegetable sources must definitely be made use of to supplement the fish liver oil. This is another major problem, but as it is not relevant to the present theme, we will now revert to further consideration of fish liver oil problems.

Shark-liver oil requires supplementing with Vitamin D.

The Cod-liver oil is naturally rich in Vitamin D. In that oil vitamin A and D are so proportioned that no further supplementing is needed. In the case of shark-liver oil vitamin A is very predominant, so that further supplementing of vitamin D will be needed to render it more balanced. Fortunately, concentrated Vitamin D preparations like calciferol are easily available at relatively small cost so that it should not be difficult to supplement shark-liver oil with Vitamin D at the blending centres. Considering the importance and the inter-relation between these two fat-soluble vitamins, it should be made a State policy to insist on the supplementing of shark-liver oil with Vitamin D before marketing.

Vitamin E is another important fat-soluble vitamin. It is not however very much missed in the average Indian diet which includes a good proportion of vegetable oils, whole seeds and so forth. It may not be necessary to add this vitamin to fish-liver oils, though it may indirectly help by acting as a stabiliser. In the case of carbotenoid concentrates however, the presence of this vitamin is considered necessary both as a stabiliser and as an auxiliary for the better use of the vitamin.

Shark-liver oil need not be diluted.

During the first few years of the shark-liver oil industry, it was considered desirable and necessary to dilute the vitamin A content to the same level as in Cod-liver oil. Groundnut oil was largely used for this purpose. This practice led to a number of secondary difficulties. It also facilitated the marketing of a number of spurious products. A good section of people find groundnut oil disagreeable; they do not use it even for cooking. Taken on the whole, it is now being increasingly felt that there is no need to dilute the shark liver oil. The concentrated product can be used as such, the dose being reduced in proportion to the concentration used in that manner the oil will also be less disagreeable. That is how halibut oil, another rich fish-liver oil is being used throughout the world.

Molecular distillation may not be necessary.

Even when used in drops, any fish-liver oil has a disagreeable smell. Several ingenious methods for taking such oils along with food have been suggested, but even then, the more fastidious people cannot miss the smell. It has been suggested, therefore that the vitamin in the oil should be concentrated free from smell. This is a very desirable object, but there seems to be some practical difficulties in the way. The possible of molecular distillation employed for the separation of the vitamin is well known and there are a number of small stills in different parts of the World. There seems to be only one big still however (in America) which is actually being used for the distillation on a commercial scale. The erection of such a still at some central place in India may not be feasible unless collaboration, a comparatively favourable basis can be established.]

Suitable packing will get round the smell problem.

Modern methods of packing have been steadily getting round the difficulty of smell. Today there are several brands of vitamin preparations on the market which are so pleasantly coated that the smell, if anything, is quite agreeable. Such vitamin preparations which often include a number of vitamins—can be swallowed without any discomfort. There is also no unpleasant after smell. If the same pleasant smelling capsules are bitten through, the strong smell of the fish oil can be noted. Judging from the smell and concentration of the vitamin, it is easy to make out that either halibut oil or shark-liver oil of the necessary high potency is being used. Molecular distilled, odourless vitamin is still not being used on a large scale even by the most reputed firms. If proper methods of packing are employed, the smell difficulty can be completely eliminated even when using the raw fish oils.

Even with the present methods of production, it should not be difficult to collect together substantial quantities of shark-liver oil having an average potency of 30,000—40,000 units per gram. Of such an oil, only about a drop will be required for meeting the daily supplementary requirements of an adult. If the calculated quantity can be properly packed in attractive capsules, the entire needs of the more fastidious section of the public can be easily met. In addition to this, there will always be the less concentrated product the daily dose of which will be a few drops. This can be easily taken if suitable dropping arrangement can be provided.

Difficulties in the way of the healthy development of the industry.

Judging from the trends of recent years, the biggest obstacle in the way of healthy organisation and scientific development of the industry is the existence of a number of independent bodies, which work rather isolated from each other. Provincial Governments, States, manufacturing concerns and others all work without sufficiently close contact with each other. Though it is not openly expressed, there is also a feeling of unnecessary rivalry with a tendency to observe secrecy in regard to the experience collected by each organisation. As the result of this, there is no useful exchange of ideas between some of the major organisations. Each organisation has its own separate agency for advertising, marketing, etc. This state of affairs stands in the way of healthy development. It also provides scope for the less scrupulous section of traders—who are under no control—for marketing all kinds of products as genuine articles. For want of proper co-ordination and concerted effort, the reputation of the industry as a whole, is suffering. Even patriotic minded medical practitioners are now hesitant about recommending Indian Shark-liver oil. Doctors with some professional reputation are very zealous about guarding them, they are naturally inclined to be conservative in the recommendations to their clients. Patriotic considerations cannot weigh much in the alleviation of suffering. The present position should therefore be reaslised in its proper perspective. The Norwegian Cod-liver oil (with its high reputation) and other well known brands will soon be on the Indian market and unless the shark-liver oil industry will unite in facing this competition, it will soon die again—just as the Malabar fish-liver oil industry died about 80 years ago. *Instead of expanding, the indsustry is in danger of extinction and it is earnestly hoped that this common danger will bring all the diverse elements together and pave the way for organised planning and development.*

There is no need for any secrecy.

At the heads of different provincial or state organisations there are administrators. These are naturally guided by their technical staff. The technical staff are inclined to keep rather close and this has created even in the minds of the administrators, the impression that there is something of a specialised nature which must be preserved confidential for the benefit of their unit. *There is in fact no need for the preservation of any secrecy in regard to the methods of production and stabilisation.* The really important factor is the supply of fish liver and if the fishing areas can be properly demarcated there is no aspect regarding which any secrecy need be maintained. In the interest of all concerned, there should be free exchange of notes. There should also be unified control to see that proper methods are followed. The standardisation and marketing can also be under joint auspices. No interest will suffer under such conditions. Fraud will be stamped out and the industry will flourish under healthy conditions. The industry can also present a unified front to secure the necessary measure of protection against unfair foreign competition.

A central, co-ordinating authority is needed.

As already mentioned, the production is now going on under diverse auspices. These are not normally likely to meet unless the Central Govt. takes some initiative in regard to the matter. Even when they meet, they should do so with a determination to work together.

Independent organisations cannot exercise any effective control unless they decide to create a Central authority. The Central authority should command their full confidence and at the same time, have necessary freedom to plan and carry out the future development.

An outstanding instance of success through a central organisation is the well known development of the Tennessee Valley. A number of independent states were involved and if they had proceeded independently nothing would have been done to this day. The development of the valley was made a Federal subject and a Central authority was created. The result is the outstanding success which stands as an example to the World.

Composition of the proposed Central Authority and their powers.

For the development of the Shark-liver oil industry, what is needed is a small Central Authority consisting a highly experienced administrator who will also represent the Government, a reputed member of the industry, who will advise on all business matters and one scientist with the requisite standing and experience.

The Authority which would work whole-time should be charged with the planning and development of the industry for the whole country and they should be given the targets with full powers to take the necessary action. Every province or state with a coast line should come under their purview. After organising production, the share of benefit for each individual province or state can be easily determined. The work of the Authority can be periodically reviewed by a bigger organisation.

The Central Government has taken up the planning of the major industries of the Country. The plans are now being drawn in big broad outlines without actually going into details. The details are however necessary for the execution of each plan and lacking them, the plans will remain vague and unexecuted.

The present note does not claim to be a plan. It only aims at taking the position a step beyond the fixing of a target. It draws attention to some of the outstanding problems and suggests a way of dealing with them. A specialised whole-time body such as the proposed Central Authority is needed to go into further details and to draw up the detailed plans to execute them. The planning and execution need not be separated.

Each item of industrial development would require such whole-time planning and execution. The planning organisations should also have the necesssary powers and freedom to execute their plans. If their work stops merely with sending reports, there will be no progress.

If the Central Government is to plan the wholesale development of industries, hundred of such organisations will be needed. This will mean a huge expense for even a very prosperous country. The available talent is also very limited. A beginning can however be made straightaway with subjects like the present one where the industry already exists. Moreover, as already pointed out, the industry is in lively danger of foreign competition which may ultimately kill it. In such a case, immediate action will be needed. All technical and other difficulties should be overcome and the industry should be not only protected but also considerably strengthened.

In the preparation of this note, great care has been taken to avoid specific reference to any individual or organisation. There may no doubt be some difference of opinion in regard to matters of detail, but the main problems are all these and they must be satisfactorily solved if the industry is to live and to flourish in the post-war period.

APPENDIX VII

A NOTE ON THE MANUFACTURE OF VITAMIN A CONCENTRATE FROM SHARK LIVER OIL.

Dr. K. Ganapathi, and Lt. Col. Sir S. S. Sokhey.

1. *Importance of Vitamin A.*—Vitamin A is one of the important vitamins and it plays a significant role in the nutrition of the children and adults. Deficiency of this vitamin retards growth, causes night blindness and xerophthalmia, and lowers the general resistance towards infection. It is very vital for children. They should receive this vitamin daily in adequate amounts in their diet. Milk and vegatables, particularly the green and leafy ones, are the normal sources of this vitamin. In addition, it is the practice in the case of children to supplement this source by fish liver oils rich in vitamin A. Because of the critical food situation prevailing in this country as a result of war, a great deal of sicknesses and other diseased conditions traceable to the deficiency of this vitamin have become prevalent. The supply of this vitamin has become one of the important problems for the Government to tackle. We require vitamin A not only for treating those who suffer from the deficiency of this vitamin but also making it available for all children upto the age of 16 years in adequate quantities for their normal growth.

2. *Quantity of Vitamin A required.*—We can take it then that ten per cent. of the population in India require vitamin A to be administered daily. The daily requirements of this, as laid down by a recent authoratitive recommendation, varies from 1,500 to 5,000 international units. Children up to the age of 10, pregnant women and lactating mothers require about 5,000 units per day. Certain amount of Vitamin A is usually taken along with the diet and we have to supplement it by extra amount where the quantities of vitamin A taken is not enough. It is the opinion of many that the children should be administered daily about 2,000 units of vitamin A irrespective of their dietary intake. So if ten percent. of the population has to be administered daily 2,000 units of vitamin A, our annual requirement of vitamin A for this purpose works out to about 30,000,000 million units.

3. *Materials.*—Vitamin A is widely distributed in the vegetable kingdom, but it occurs in a much greater concentration in some fish liver oils, particularly so shark liver oil. We are fortunate in having a long sea coast which abound in sharks yielding liver oils of high petency of vitamin A. The extraction of the vitamins from these liver oils is much easier than that from the vegetable sources. Becuase of these important reasons, the shark liver oils become the main and cheap source of vitamin A for us. Shark liver oil, even if manufactured with utmost care, possesses some disagreeable odour and taste. But the vitamin fraction free from this odour can be separated out from the oil by chemical methods or much better by molecular distillation. Such a vitamin fraction obtained can, if required, be flavoured to any desirable degree and also be blended easily into any composition to furnish an attractive preparation.

4. *Quantity of Shark Liver oil required.*—The bulk of the shark liver oil available to us are of average potency of about 10,000 units of vitamin A per gm. The preparation of the vitamin concentrate from the oil involves a slight loss. So to prepare 30,000,000 million units of the vitamin A concentrate, we need roughly one million gallons of shark liver oil of average of 10,000 units of vitamin A per gm. We are not able to obtain reliable figures for the present production of the shark liver oil; however, the director of Fisheries, Bombay, infoms us that the total production of shark liver oil in India would be about 30,000 gallons per year. Considering the present state of the industry and the anormous scope there is for improvement and expansion, we are convinced that it would be possible to reach the target of one million gallons per year if this industry is properly organised. We have disucussed this question with the Director of Fisheries, Bombay, and he agrees with our views.

5. *The Production of Shark Liver Oil*—At present, the production of shark liver oil is going on under the auspices of some Government Departments and also some private agencies. The most important single step in the production of the oil governing the quality and vitamin A potency of the oil, is the extraction of the oil from the fresh livers under scientific control. This process of extraction must be conducted on much more scientific and modern lines. To put this industry on a firm basis, the Governments of Sind, Baroda

Bombay, Madras and Travancore should co-operate with each other and then strengthen their Fisheries Departments. With the labour available in India which is cheap compared to the Western standards, the abundance of sharks in our waters which yield oils of high vitamin A potency, and requiring no chemical to be imported for the extraction of the oil from the livers, we can be confident that this industry, if properly organised, should be able to withstand competition from any part of the world.

6. *The price of Shark Liver Oil.*—It is difficult to make an estimate of the actual cost of the shark liver if manufactured under Government control without private profit element. The present market prices give no indication because we do not know the degree of profit involved. However, the Haffkine Institute is buying shark liver oil from the Department of Fisheries of the Bombay Government and the prices are as follows —

Potency of Oil Units of vitamin A per gm.	Price per gallon. Rs.	 As.	 Ps.
10,000	20	0	0
15,000	23	12	0
20,000	30	0	0
25,000	32	0	0
30,000	35	0	0
40,000	37	8	0

It can be seen that the price is not proportional to the vitamin content. The bulk of the oil obtainable possesses an average potency of 10,000 units per gm. and we will here take only this brand of oil into consideration tentatively. On the basis of the price paid for the oils of potency of 10,000 units per gm. the price of one million gallons of shark liver oil works out to two crores of rupees. So an industry with such an amount of turn over should be put on a modern and proper basis and can claim a greater degree of attention from the Governments.

On the basis of the price of the oil of potency of 10,000 units per gm., the price of 1,000 doses of shark liver oil each containing 2,000 units of vitamin A, works out to roughly Rs. 1-2-0; thus the quantity required by one individual per year costs about Rs. 0-6-6.

7. *Preparation of Vitamin A concentrate by molecular Distillation.*—There are two methods of obtaining vitamin A concentrate from the shark liver oil. The one is by chemical processes and the other is by molecular distillation. The first process has been well investigated in the Haffkine Institute and is actually being used. But we do not recommend this as the best one for the following reasons :—In the first place, to concentrate one million gallons of the oil, chemicals costing about Rs. 35 lakhs are required ; besides a good deal of equipment. In the second place, the vitamin A fraction represents just five percent. of the bulk of the oil and to recover this, we destroy the rest of the oil by converting into the calcium soaps. Thirdly, during the process of saponification, the vitamin esters of the oil are converted into the free alcohol which is less stable than the esters. Molecular distillation avoids these three drawbacks.

By distilling the shark liver in a molecular still, the oil can be stripped off its vitamin fraction which is obtained in a very clean and attractive form free from the objectionable odour and taste. The bulk of the residual oil representing about 80 per cent. of the original volume is also rendered odourless by the process and this is available for feeding and also other industrial purposes such as for the leather industry, preparation of turkey red oil, paints, dopes etc. Vitamin A obtained from the shark liver oil by industrial distillation exists in the ester form along with the tocopherol fraction, which is the stabilising agent of vitamin A in the oil. Because of these reasons, molecular distillation of the oil has been taken up in U. S. A. The Industrial method consists in the distillation of the oil in the centrifugal rotating plate stills under very high vacuum. In 1936, when molecular distillation on an industrial scale was still in its infancy and was being carried out on a pilot plant scale, enough vitamin A esters were produced to meet a tenth of the entire demand in U. S. A. Even this pilot plant could distil about 100 gallons of the oil per day. Today, in the Laboratory of the Distillation Products Inc. (Rechester), there is in operation a unit consisting of a battery of 21 stills of 32 inch plates exclusively for the distillation of fish liver oils. With this in 1943, nearly 5 million pounds of shark and pollack liver oils were distilled. Recently, the Distillation Products have been experimenting with the construction of higher stills. The rotating plate still of 60 inch constructed has a capacity of 500—1000 lbs. of oil per hour. Another still is said to be under construction which can distil an even larger quantity of the oil per day. This shows that it is quite easy to subject the entire quantity of the shark liver oil produced in India to molecular distillation.

Molecular distillation is comparatively a cheap process. The recurring expenses consist mainly of the cost of power required to drive the stills. To distil one million gallons of the oil in the stills of the type recommended below, the total expenditure, including the depreciation on the capital; will be about 6 lakhs of rupees, it will not in any case exceed 10 lakhs of rupees. The cost of the vitamin fraction obtained from 1 million gallons of shark liver oil (of average potency of 10,000 units per gm.) will be 210 lakhs of rupees. So 1000 doses of vitamin A concentrate of 2,000 units each obtained by this process will cost about Rs. 1-6-0. There is then the income from the residual oil. By distilling one million gallons of the shark liver, we will be left with about 800,000 gallons of the residual odourless oil. Even if disposed of at Rs. 2/- per gallon, this residual oil will fetch an income of Rs. 16 lakhs.

8. *Number of Molecular Distillation units required and their location.*—To concentrate about one million gallons of shark liver oil per year we require a battery of stills. It is better these stills are put in the five localities wherein the shark liver oil will be produced. If we have one centralised unit, all the various stations along the entire coast producing the oil have to send the oil to this place and then take back the processed products from here. This will involve considerable expense and also inconvenience by way of transport. So, each of the Fisheries Departments of the five Governments concerned, can have one molecular distillation unit with a capacity to distil about 400—600 gallons of oil per day. These units could be located at Karachi, Baroda, Bombay, Calicut, and Trivandrum. Initially, we may not produce enough oil to engage the five units. The quantity of oil produced at present can be distilled by one unit alone. So to start with, we should obtain one unit and locate it at either Bombay or Calicut, which produce at present the largest quantity of the oil. As the production of the shark liver oil increases, we can gradually have the units in the other places also.

9. *Cost and Availability of the Molecular distillation units.*—The process of manufacture of the vitamin A concentrate from the liver oils by the "short-path" distillation method (Molecular distillation) is covered in a patent owned by the British Drug Houses. It is anticipated that there will be no difficulty in obtaining licence. This firm has agreed to grant the Haffkine Institute the licence rights. The molecular stills of the industrial type we require are manufactured by the distillation Products Inc., Rochester, at present and we can obtain the stills only from this firm. Two years ago, the Haffkine Institute approached this firm for a rotating plate still with a capacity of about 50 to 75 gallons per day. But because of the abnormal world situation prevailing then, this firm could not fabricate this unit at that time and informed us that this matter be taken up at a later date. A unit with a capacity of 50—70 gallons per day costs about Rs. 80,000 while a bigger one with a capacity of about 400 gallons per day costs roughly Rs. 1,50,000. We require units of the latter type for each of the Fisheries Centres proposed. So all the five units will cost about Rs. 7,50,000. To negotiate this transaction successfully, a body with the technical and administrative experience and with the authority of the Government should contact this firm and then decide upon the terms of contract and the types and designs of the stills. We do not anticipate any difficulty in this. This should be done at any cost in the interests of India. We, who have got to bring practically everything anew in the industrial field, have an opportunity to start with upto-date equipments and processes. These molecular distillation units will not only be furnishing us with what we want but also serve the purpose of educating others in this important and useful modern process which has got great possibilities in India.

10. *How this industry is to be managed.*—The supply of vitamin A concentrate is an activity that must be undertaken by the state. This concentrate must be within the reach of all the poorer sections of the community and so this should be as cheap as possible. Comparing the cost of vitamin A prepared from shark liver oil as given under para. No. 7 with the market price of the preparations manufactured by the private firms, we arrive at the conclusion that the manufacture of shark liver oil and also the preparation of the vitamin A Concentrate by molecular distillation shall be under state control.

APPENDIX VIII

NOTE ON TARGETS FOR FINE CHEMICALS.

(*Dr. J. N. Ray.*)

Phenatidine	It is an important chemical not only for the drug industry but has its use in other industries. Therefore, a target of 200 tons would seem to be justified.
Phenacetine	Target 50 tons. It is for the medical members of the Committee to find out whether this is a correct estimate. Judging by the pre-war consumption I should think 50 tons to be quite reasonable.
Resorcinol	Used in the dyestuff industry. Simple dyes like rosin are prepared from this. Hence 25 tons target was suggested.
Cresols	Judging by the amount of consumption of saponified cresol lysol in this country, a target of 1,000 tons is not unreasonable.
Xylenol	Used for the preparation of dettol type of disinfectants. Xylenol is to be converted into chloroxylenol and then into dettol type of disinfectants. The target can be reduced if the medical members feel that India cannot use 5,000 tons of dettol type of disinfectants. (500 tons of xylenol will give approximately 5,000 tons of these disinfectants).
Acetic anhydride	Dyestuff industry needs 100 tons. Target suggested is 250 tons. Acetic anhydride would be considerably used in the rayon industry, whose requirement would be another 100 tons. The balance would be readily absorbed by the drug manufacturers.
Benzaldehyde	This is used in the perfume industry, as also in the manufacture of dyestuffs. An immediate target of 20 tons is quite a reasonable quantity to adopt.
Phthalic acid	This would be required for glyptal type of resins. We have 1,000 tons of naphthalene in surplus production and every bit of it will have to be converted to phthalic acid, because its use as an insecticide does not consume the whole quantity. I think 100 tons should be our immediate target.
Agar	Pre-war consumption between 2 to 3 tons. Immediate target 10 tons. There is likely to be an increased requirement due to improved health services.
Citric acid	Aerated water industry used nearly 200 tons. Extra amount provided is for Health Services.
Monochloro acetic acid	Required for the preparation of various synthetic drugs like Adrenalin and also for weed killers. Target of 100 tons is very modest.
Stearic acid	Required for shaving sticks, cosmetics, anti-mosquito cream, vanishing creams. Normal consumption about 200/300 tons. Target 1,000 tons.

Barium Peroxide	100 tons—based on a requirement of nearly 50 tons of hydrogen peroxide.
Calcium and Sodium	The target will have to be calculated on the basis of the target fixed for anti-malarial drugs.
Activated Carbon	250 tons—both for medicinal and decolourising purposes. The requirements of the sugar industry has also been taken into account.
Starch	Present production about 300 tons. Required for cosmetic industry, medicines and in textiles. Target for 1,000 tons very modest quantity.
Camphor	Required for celluloid industry and also for medicines. The requirement of celluloid industry is very large.
Glycerine	Present production 2,000 tons. Target set 4,000 tons. Required for endless number of items.
Formaldehyde	Required for the plastic industry. Medicinal requirement about 100/150 tons.

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APPENDIX IX.

SOLVENTS.

(Dr. J. N. Ray).

If India is to produce fine chemicals and synthetic drugs, the most essential requisite is that India should have a well organised solvent industry and solvents should be available at a cheap and reasonable price.

The following are mostly in the fine chemical industry:—

1. Alcohol (ethyl)
2. Methyl alcohol
3. Acetone
4. Acetic Acid
5. Ethyl acetate
6. Butyl Acetate (amyl acetate)
7. Ether
8. Chloroform
9. Carbon tetrachloride.
10. Vynyl acetate
11. Chloroethylenes
12. Glycol & Glycol esters
13. Furfuryl Alcohol
14. Carbon bisulphide
15. Sulphur chloride
16. Benzene
17. Toluene
18. Nitrobenzene
19. Xylene
20. Pyridine
21. Dioxan
22. Glycerine.

Alcohol.—India's requirement of alcohol for medicinal purposes so far as Defence Services and Government civil demands are concerned has been approximately 100,000 gallons per year. The country's total requirement on this basis will be approximately one million gallons per year. If the industries expand as has been visualised in the first meeting of the Fine Chemicals, Drugs & Pharmaceuticals Panel, then it is proposed that we should have a production target of 10 million gallons of alcohol for various purposes, to be attained during the next 15 years. At present the production of acetone and methyl alcohol is extremely limited. A certain amount of acetone has been prepared in the Ordnance Factories from ethyl alcohol and a small amount has been produced by Messrs. Bhadravati Iron & Steel Works. We feel that the production of methyl alcohol and acetic acid from Wood is not going to be an economical proposition. India should aim at a production target of at least 100 tons of methyl alcohol per annum increasing it as industries get established. With regard to acetone, its employment in the lacquer industry is its principal outlet at the present moment. Acetone is also used as a solvent in the drug industry but the total amount used by the drug industry is only a small fraction of its employment in other directions. Therefore, in formulating plans for the production of acetone, other panels connected with the subject should be consulted.

Acetic Acid.—The present production of acetic acid is negligible. Acetic acid will play an important part in the development of the pharmaceutical industry and also will act as a starting material for the preparation of acetate type of solvents such as vynyl acetate, ethyl acetate, butyl acetate. Here again the total production target should be fixed in consultation with other panels but in my opinion we would not be wrong if we set a target of at least 1,000 tons which India would be able to consume immediately. The production of acetic acid via the oxidation of alcohol is the route to be chosen as wood distillation would not be a success except in such parts of India where there is a demand for wood charcoal. With plentiful supplies of alcohol available at a cheap price, the production of acetic acid by oxidation of alcohol should be a commercial proposition.

Acetate Solvents.—Acetate type of solvents such as ethyl acetate, butyl acetate, will be required only in small amounts in fine chemical industry, the principal amounts will be consumed elsewhere. In my opinion, taking all demands into consideration, we should aim at a production of 1,000 tons of acetate type of solvents immediately.

Ether.—We have already stated in the first meeting of the Panel that ether is not a suitable solvent of choice in India owing to high climatic conditions involved. The country's requirement of ether anaestheticus is roughly about half a million pounds per annum. The capacity exists in India. We would not be justified in putting a production target for ether as this solvent should be avoided if it can be helped. But we feel that there is ample production capacity existing with the present manufacturers and any demand for solvent ether would be easily met by these firms already in production. The present high cost of ether in India, apart from climatic disadvantage, makes its use in industry an expensive luxury. This is due principally to the high cost of alcohol prevailing. It has been calculated that if alcohol is available at 6 to 8 annas a gallon, ether of solvent quality can be produced in India to compete successfully with all imported stuff. It must be borne in mind there is heavy loss in transit when ether is imported from abroad. This gives the Indian manufacturers a natural advantage.

Chloroform.—The first meeting of the Panel had set a production target of quarter million lbs. of choloroform per annum for anaesthetic purposes. We feel that for the solvent purposes, another three-quarter million lbs. would be easily consumed.

Carbon Tetrachloride.—The present figure of half a million lbs. of carbon tertrachloride and tetrachloroethylene which has been decided at the first meeting of the Panel should be sufficient and it is presumed that any extra demand needed for the solvent industry can be easily met from the firms that would be producing, the articles for pharmaceutical purposes.

Vynyl Acetate.—This is an important solvent but its most important use is in the production of resins. The production target for this item should be decided in consultation with the Panel on Plastics.

Glycol.—It is felt that for the present a target of 1000 tons should be more than sufficient but here again glycol and glycol acetate are the concerns of other industries such as Aircraft Producton, Paints & Varnishes.

Carbon Bisulphide.—An attempt has been made to produce Carbon bisulphide in India but it has apparently not been successful to any great extent. This is an important solvent for the rubber industry and the panel on rubber should be consulted with regard to the total quantity required. Carbon bisulphide is also used as a starting material for the synthesis of various sulphur compounds.

Sulphur Chloride.—Sulphur chloride is mostly used in vulcanisation. It is not known what are the plans with regard to the rubber industry. But if it is decided to have a worthwhile vulcanizing industry developed in India, it is felt that step should be taken to produce at least........tons per year. The existing vulcanizing firms use considerable amount of this important chemical whose preparation would not be very difficult if chlorine is available at a cheap cost (sulphur of course will have to be imported).

Benzene & Toluene.—We have already stated that a million gallons of benzene and half a million gallons of toluene are being produced in India. This should suffice for the present, but the production should be kept up.

Nitro-Benzene.—This chemical is used in the perfume industry and also as a solvent in the fine chemical industry. Benzene would be available and the production of nitrobenzene on a large scale would be needed if any plans have been set up for the production of aniline in India. The Committee for Dyestuffs would set up a production target for aniline and we feel that if any production of aniline is undertaken in India, no special arrangements need be made for the production of nitrobenzene.

Xylene.—India's production of Xylene at present is 54 tons per annum. We feel that to start with this would be enough but one possible use to which xylene may be put is as a solvent for DDT. For the latter purpose, very large quantities of Xylene will have to be produced but I am afraid it may not be possible to step up production immediately as Indian coal is carbonised in an unsuitable manner and the yield of xylene is not very high.

Pyridine.—Large quantities of Pyridine would be neeeded for the manufacture of M.B. 693. Pyridine is also used as a solvent in special cases. We have set a target of half a million lbs. for sulpha drugs. It occurs to me that at least half a million lbs. of Pyridine will have to be produced.

Dioxan.—This will be again a byproduct of ethylene glycol industry. No special target need be set for it.

Glycerine.—India has been producing 2,000 tons per annum. This is many times more than her normal requirement. This will embrace not only her requirements for pharmaceutical and medicinal purposes but also for other industrial uses. At the present moment, owing to the dimunition of defence demands, large stocks of glycerine are accumulating. It is suggested that steps be taken to utilise this glycerine for the production of acroline and various types of resins needed for plastic industry. The Panel on Plastics may be consulted and asked to state their requirement of glycerine for acrylic and glyptol type of resins.

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APPENDIX X.

NOTES ON THE MANUFACTURE OF VACCINES, ANTI-TOXINS AND SERA

(Lt. Col., Sir S.S. Sokhey, I.M.S.)

A.—Bacterial Vaccines.

Vaccines.—Since the close of the last century when prophylaxis against bacterial infections, such as plague; cholera, typhoid, with vaccines became possible, Government has organised a number of medical research laboratories, one of whose important activities, among others, is the production of bacterial vaccines. There are at present six such laboratories distributed all over India ; Haffkine Institute, Bombay, (1896), King Institute, Madras (1903), Central Research Institute, Kasauli (1906), the Pasteur and Medical Research Institute of Shillong (1917), the Provincial Hygiene Laboratory, Lucknow, (1931), the Cholera Vaccine Laboratory, Calcutta.

The Government laboratories have, among them a vaccine production capacity of about 8 million cubic centimeters per month. This production can be increased if larger quantities of vaccines were needed. In addition to the existing Government laboratories, it is recommended that all the Provincial Governments should organise these provincial Government laboratories in the near future. These new provincial laboratories should also take vaccine production work and thus increase the vaccine production capcaity of the country.

The present production capacity of the country is ample and is likely to be added to in the near future. No further action is suggested at present.

B.—Rabies Vaccine.

In 1900, Government established the Pasteur Institute of India at Kasauli. Since then all the Government laboratories named in the note above have taken up the manufacture of antirabic vaccine. In addition, Government has established two other laboratories specifically for the preparation of antirabic vaccine and for the administration of treatment ; The Pasteur Institute of Southern India, Coonoor (1907), The Pasteur Institute of Calcutta.

These laboratories are meeting, among them, the needs of the country as regards the vaccine adequately. A large number of treatment centres have already been opened all over the country and there is no doubt that more will be opened as medical relief organisations of the country develop.

C.—Vaccine Lymph.

Vaccine against small-pox is manufactured at seven Government laboratories situated at Ranchi (Bihar), Nagpur (Central Provinces), Guindy (Madras), Calcutta (Bengal), Patwa Dangar (United Provinces), Lahore (Punjab), and Belgaum (Bombay).

These laboratories, among them are meeting the needs of the country adequately. Should demand for more vaccine lymph arise, there is no doubt these laboratories would be in a position to expand their production, or Government will organise more laboratories.

Anti-toxins and Sera.—Until the end of World War I, India depended entirely on foreign imports for its supply of antitoxins and sera. In 1919, a beginning was made by a commercial firm, but it was many years before the firm could produce sera in any quantity. Since then, a number of other firms took up manufacture. In spite of their efforts, large quantities of antitoxins and sera continued to come from abroad.

In 1940, Government organised the production of antitoxins and sera at the Haffkine Institute. This project had two objectives ; firstly to put up an ideal set-up for housing the animals and for processing the sera, so that it may set standards for such work in the country and secondly to produce high quality sera in large quantities to make the country independent of foreign imports.

No data are available as to the volume or value of sera imported into the country. Evidently, the Custom Department does not separate sera from other drugs. So it is difficult to say what the needs of the country are, but it is safe to say that because of the small number of hospitals in the country and the very limited resources at their disposal, the quantity of antitoxins and sera used at present is not large. But whatever the demand it is being successfully met at present by the Indian production, as during the war all foreign imports were cut off.

There is no doubt that the demand for sera will gradually increase as the medica relief organisations of the country develop. Against this, it is to be noted that the Madras Government is organising a department of antitoxins and sera production at King Institute, Guindy. I t is believed that as Provincial Governments develop their bacteriological laboratory services, they will take up serum production, as in America and Europe. The production of biological products under Government auspices is a well-established practice in the country and Government will take up further production as it becomes necessary. No recommendations require to be made at this stage.

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APPENDIX XI (*a*).

NOTES ON THE EQUIPMENT FOR DRUGS, FINE AND PHARMACEUTICAL CHEMICALS.

(*By Mr. N. Adhikari*).

Pharmaceutical and fine chemical manufacture covers a very wide field varying from refining of common salt to the manufacture of Penicillin. Inorganic and Organic substances occuring in nature along with many synthetic and semi-synthetic Organic, Organometallic, inorganic, and many biological products are at present employed in medicine. To produce the desired drug or chemical, chemists and Chemical engineers together have to solve many problems both chemical and constructional relating to the isolation or synthesis of the substance in view.

There are many organic compounds which are of plant origin. The manufacture or isolation of these compounds comprises of varying processes of extraction followed by concentration and removal of adherent substances which yield the crude extract or sometimes the pure product. Many substances which used to be regarded as of naturally occurring plant or animal products only, are now successfully and more economically made by synthetic process, as for example l-ephedrine, Adrenalin, Vitamin B1 and C etc. However it is immaterial whether the particular item in view is to be synthesised or extracted from some naturally occuring substances in as much as the manufacturer has always got to solve some problems special for his purpose, only because there are a few standard equipments for the manufacture of even half a dozen of drugs or fine and pharmaceutical chemicals. Almost in all cases plants differ in arrangements and fabrication according to the convenience and particular need of the manufacturer in general and availability of the materials required for the plant in particular. Again, the principles of operation remaining the same the plant for a particular product may be different in different manufacturing concerns depending upon the use of Chemicals as solvents. This is true for the extraction or isolation of substances, but in complete units in operation at different places though engaged in the manufacture of the same product—there is every possibility of finding standard units such as Sulphonators, Nitrators, or Hydrogenators as common components of the plant in which these steps are essential. The manufacturer will have his own extraction or isolation plants made according to his own design—economically fabricated with the materials he can easily secure and suitable to the particular chemical he is going to use. But when the problem of Sulphonation or Nitration is to be worked out it is most likely that one will make use of units made by reputed firms invariably foreign who are in a position to guarantee the life of such equipments under different working conditions by dint of their experience in the line. This is also true for other processes which will require the use of vacuum pumps, super-centrifuges etc. or thermocouples and other precision measuring instruments.

Due to the high standard of purity at which most of the drugs and fine Chemicals are required by regulation, corrosion-resistant equipments are to be employed in most of the operations. Much difficulty is encountered by Chemical engineers in India in constructing such plants for want of proper and suitable corrosion-resistant materials such as Stainless-steel, Monel, Inconel, rubber lined stills and vessels etc. None of these materials, as well as high grade glass Silica or enamel wares which are almost indispensable for any manufacturing concern as ancillaries are made in our country. This is a great handicap to our chemical industry in general and efforts should be made without delay to remove it. India is entirely dependent on her import trade for such capital goods.

For want of proper materials with desired specification our engineers are obliged to use whatever best they can find in the market, which is never upto the mark aimed at and consequently the plants constructed out of them can be seldom worked on for the period it would normally last in case it could be made with materials of correct specification. This in the final tells on the production cost of the drugs and Chemicals concerned. Although several thousand tons of cast iron wares are made in this country for every day use very few of the firms are agreeable or in a position to make any declaration of the composition of the wares made by them.

If proper materials could be had from abroad or produced here in our country many of standard equipments mentioned before could be made locally. It is not so much the dearth of proper technical skill what stands in the way of making standard appliances here in our country as does the want of proper constructional materials having the specification required by the process. Fabrication has been possible here for machine guns to bridges which are mechanically not very different from fabrication of chemical plants and equipments. In spite of this, big chemical plants have not been built up here. This is due to two factors—one—dearth of materials of choice for the purpose and the other—it has so far not proved worthwhile for big and competent engineering firms to take up this line for want of regular demands from the chemical industry due to its stunted growth.

It has been observed that manufacture of drugs and chemicals—fine and pharmaceutical—involve a series of operations and also that some of these operations are at present carried out with the help of standard equipments imported from abroad. Such units may be classified as under :—

1. Crushers, Ball-mills, Hammer mills, Pulverisers with air separators.
2. Classifiers (screening and separation).
3. Thickners, Clarifiers, Rotary drum filters under vacuum filter processes.
4. Evaporators—Arrangements for using sun-rays, those heated by direct fire (cauldrons, panbaths), those with heating medium in jacket, steam heated evaporators with heating surface in the inside or outside of tubes, plain or under vacuum, single or multiple stage.
5. Centrifuges and Super-centrigufes.
6. Air compressors, centrifugal pumps and other general equipments.
7. Sulphorators, Nitrators and Hydrogenators.
8. Driers—Spray and drum driers for liquids ; Pen, Rotary and Tunnel including tray driers for solids, and vacuum driers.
9. Mixers—gas with gas, gas with liquids, liquid with liquid, liquid with solid, solid with solid; flow mixers, paddle mixers, propeller mixers, and other different varieties.
10. Deodourisers ;
11. Crystallisers—Classifying
12. Rectifiers, heat exchangers.
13. Refrigerators.
14. Dust catchers.
15. Low temperature distillation equipments (R.C.A. Type).
16. High temperature and pressure working equipments such as, valves, gauges, indicators etc.
17. Acid and Corosion-resistant enamel wares.
18. Glass, silica and porcelain wares.

At present almost all of these equipments are imported from abroad. Much attention has not been paid towards the manufacture of these units here in India for want of proper material in general but particularly for absence of any regular market for them in our country, where there are only very few enterprises which are in need of such appliances and equipments. The cheap man power which was so long been available in this country in abundance, induced the industries to depend more upon it and made them shy of using machineries in places where possible as the latter needed more capital investment at the outset. As a result no attempt was made for mechanisation of any industry thoroughly excepting the major ones. The machine sense of the mass is still very poor but there is some indication at least among the different industries, that people are being alive to the many fold usefulness of mechanisation. Besides, our drug as well as fine and pharmaceutical chemical industries have taken a definite turn towards large expansion, so no time should be allowed to be wasted in taking up the building of our chemical plant and machinery industry. Much difficulty will not be encountered in manufacturing most of the above equipments here, provided the task of making suitable ferrous and non-ferrous alloys be taken up by the metallurgical industries. Side by side effort should be made to produce electrical machineries suitable to serve the specific duties under abnormal circumstances in the Chemical Plants. Chemical industry depends very much upon electrical power and applicances sometimes as power and sometimes as an essential raw material, and hence full scale development of it (Chemical Industry) cannot be conceived of if this branch of the industry does not grow up simultaneously.

The possibilities of manufacture of standard equipments in our country are as under:—

(1). *Crushers, Ball-mills, Hammer-mills, Pulveriser with air separators.*—These are machines for reducing the size of the raw materials before they are put into the extraction of reaction process. This is very necessary operation in Chemical plants and different machines are employed for different kind of material depending on its physical properties, quantity and feed-size. The physical properties of the main parts of these equipments are very important and should be given due consideration when designing such a machine. The most important parts in such machines are their beaters or rollers which are usually made of special steel alloys. If effort be made to produce necessary alloys for these parts, making of these equipments will not prove very difficult. Air separators which are to be used in conjunction with pulverisers are more complicated in design than material used. It may be somewhat difficult to make these just at present.

(2) *Classifiers*—(Screening and separation).

Making of these is a question of design as well as availability of suitable materials such as wire nettings of fine mesh etc. To skilled technicians it is not likely to be a very hard job.

(3) *Thickness, clarifiers, Rotary drum filters under vacuum, filter pressers.*—Making of these equipments is mostly a matter of design according to necessity and nature of work, and the materials generally used are not scarce except vacuum pumps and its equipments.

(4) *Evaporators.*—Arrangement for using sun-rays, those heated by direct fire (Cauldrons, pan-bath) those with heating medium in jacket, steam heated evaporator with heating surface in the inside or outside of tubes—plain or under vacuum, single or multiple effect:—

When sun-rays are utilised for evaporation it becomes a simple question of making arrangements for exposing a large surface of the solution to it and require little engineering skill or technique. But for making other various types of evaporators necessary for different kind of work it will require much technique both in design and in construction. All the materials largely used in making these are also not available here in the form required. Vacuum pump with its accessories are other components of these appliances. When all these will be available, big engineering firms should take up this line.

(5) *Centrifuges and super Centrifuges.*—Stainless steel and high tensile steel, corrosion-resistant alloys are some of the materials essential for making these equipment. With the materials mentioned above and high speed motor in hand, it will not be very difficult to make some of these applicances of simpler type. The advanced and most up-to-date ones require special designing skill and constructional technique which we lack for the present.

(6) *Air Compressors & Centrifugal Pumps and other general equipments.*—In modern plants these appliances are almost indispensable for transfer of liquors from one stage to another. There is not much of design in them, and it is more a question of having suitable material than anything else to make these especially the pumps. While the compressor may be made out of materials that will be able to stand the pressure desired, the pumps may require special alloys to stand the action of the Chemical as they will come in contact.

(7) *Sulphonators, Nitrators, Hydrogenators.*—Manufacture of these units will be possible when proper cast iron and enamelled-wares will be available.

Enamelled-wares and corrosion-resistant wares play a very important part in modern chemical industry and these are not only essential for making the above units but they are invaluable in the shape of, concentrators, mixing and stirring of vessels for manufacture of fine Chemicals and Pharmaceuticals. Immediate step should be taken to develop this important industry in our country. This industry again will solely depend on our metallurgical industry whence it is also to have special alloys to stand enamelling.

(8) *Driers.*—Spray and drum driers for liquids ; Pan, Rotary and Tunnel including tray driers for solids, and vacuum driers :—Necessary materials for these appliances are not very hard to procure. Large engineering firms of our country should take up this line of manufacture. There are already a large number of these under use in the different Cement Factories.

(9) *Mixers*—Gas with gas, gas with liquids, liquid with liquid, liquid with solid, solid with solid ; flow mixers, paddle mixers, propeller mixers, and other different varieties. Primary mixing came into use long back but no scientific development has yet been noticed. This subject is not difficult although economical mixing is a problem by itself and needs study.

(10) *Deodourisers.*—This is also a type of appliance that requires more skill in design and that done, the rest will not prove difficult to fabricate by any of the present big engineering firms equipped with modern tools.

(11) *Crystallisers*—Classifying—It is doubtful whether extensive work has been done regarding the development of this appliance in our country. The design of this kind of equipment largely depends on the climate condition of the place of operation. The materials generally used are not very difficult to procure.

(12) *Rectifiers, heat exchangers.*—These equipment are not very difficult to make. Large engineering works of our country should take up the design and construction of these according to the necessity of the manufacturers ; materials required are also available except in few cases of special work.

(13) *Refrigerators.*—If fractional H.P. Motors are available these equipments may be made here but the refrigerant especially the modern ones are to be imported.

(14) *Dust Catcher.*—This equipment though not largely in use up-till now in our country is sure to play an important role in future for reasons of health and also economy and attention should be given to develop it. It is more a question of design to be drawn up according to the problem in hand than anything else.

(15) *Low temperature distillation equipments. (R.C.A. Type).*—These are very modern accessories and though very useful yet, it is not likely that such type of appliances will be made in our country in the near future, unless very special attention is given, to it.

(16) *High temperature and pressure working equipments such as, Valves, Gauges, Indicators etc.*—Much work has not been done in our country in these lines, and as such this side of industry is almost unexplored. So far as we are concerned, high pressure work is coming in the forefront of the chemical industry very quickly and it is the talk of the day. There is much doubt whether we have enough high pressure technicians to design and operate this class of equipments. Before going in for making the appliances needed for this work it will be wise to make special effort to develop high pressure research work in some Government Institute.

(17) *Acid and corrosion-resistant enamel wares.*—This has been discussed under item No. (7).

(18) *Glass, Silica and Porcelain Wares.*—What is true for enamelled wares is also true for this ancillaries. Modern fine chemicals industry in particular and others in general are largely dependent on these wares. This industry has got to be developed immediately on a scientific basis to remove great many troubles associated with our Chemical Industry. Minerals and Chemicals required for these industries are mostly available in India and there should be no difficulty in producing high grade glass, silica and porcelain wares in our country, under proper guidance.

It is to be noted that the above list does not include some common equipments such as :—

(1) Extractors and Percolators.

(2) Ordinary Condensers.

(3) Roasters and furnaces.

(4) Ordinary centrifugal pumps.

(5) Air conditioned chambers.

Which are designed and fabricated here by the manufactureies, according to their necessity. It has also been observed that these appliances cannot be used satisfactorily for the normal period as they are perforce made with low grade materials. Iron sheet, Copper sheets, Aluminium sheets, Brass Sheets and castings of Gun-metal, steam pipes and cast iron pipes, cocks, valves and pipe fittings are some of the common accessories that are mainly used in constructing these plants. To some extent these items are now-a-days made in our country though not always up to the standard in quality. Efforts should be made to improve the quality of these accessories which will go in minimising the production cost of the chemicals to a considerable extent.

It appears that proper training for designing equipments for the Chemicals industry has already been neglected much to the detriment of the Chemical industry and thereby to the health and wealth of the country. Large resources in men and minerals could not be utilised for the good of the country mainly for this reason. It is true that the Chemical industry tried to forge ahead independently but it has now proved to be almost a failure. For the harmonious development of the resources of the country through the Chemical industry, it is imperative to have in the country engineering firms capable of making modern plants and appliances required by the Chemical industry. No planning for Fine Chemicals and Pharmaceuticals is likely to attain great success unless simultaneously the development of Chemical engineering industry is fostered. For this it may be necessary to acquire foreign patent rights for designs and drawings of special plants and equipments to overcome handicap of 50 years which we have already wasted.

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APPENDIX XI (*b*).

SUPPLEMENTARY NOTE ON MACHINERY EQUIPMENT.

(*By Mr. N. Adhikari*).

In my note on the equipment for Drugs, Fine Chemicals and Pahrmaceuticals, I have as far as possible stated which of them could be made here in India. As regards the quantities and cost of different equipments that will be required it is rather difficult to say anything which may even be called very approximate as different processes are adopted in different countries depending upon the nature of the raw materials available. It will however be more expensive so far as the cost of equipments is concerned if the target figure of production is to be attained by stages than if we aim at establishing factories capable of turning out the same quantities from the starting. For the later purpose, I think a sum of Rs. 120 lacs will be a moderate figure for all the foreign equipments only that might be required for all the items of manufacture in view, including those of synthetic and photo-Chemicals but excepting suplha drugs antimalarials and Penicillin.

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